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TABLE OF LEADING ARTICLES.

The Decorative in Engineering Work.............. 85
Handling Electrically-Driven Valves............... 85
The Ageing of Mild Steel......................... 86
The Control of the Septic Tank Process............ 86
The Completion of the Los Angeles, Cal., Outfall Sewer. (Illustrated) 88
The Influence of Bond on Size of Reinforcement Bars for Concrete. (Illustrated).................. 91
Cofferdam Excavation for a Power Station. (Illustrated) 92
Experience with Concrete in Fortifications.......... 92
The Predetermination of Train Resistance.......... 93
A Reinforced Concrete Observation Tower. (Illustrated) 94
Burning Illinois Coal Without Smoke.............. 95
Structural Features of the Railway Shops at Parsons, Kan. (Illustrated) 97
The Final Decision Regarding the Septic Tank Patents 99
Mechanical Plant of the Stuyvesant High School, New York, Part II. (Illustrated)............... 103
Preservation of Steel Reinforcement in Concrete Structures 105
A New Type of Forms for Concrete Work. (Illustrated) 106
Tuberculation and the Flow of Water in Pipes..... 106
Garbage Disposal in Milwaukee.................... 107
Some Unusual Welded Steel Pipe Work. (Illustrated) 109
Large Hydro-Electric Projects in Colorado.......... 109
Book Notes 110
Effect of Dryness on Concrete Mixtures............ 111
The Failure of Large Beams....................... 111
The Permanent Way. (Illustrated)................. 112

The Decorative in Engineering Works.

The everlasting problem of the decorative as against the purely utilitarian constantly turns up in the design of all sorts of engineering structures, from bridges and reservoirs to engine rooms and chimneys. There are two distinct classes of architects and engineers ceaselessly opposed to each other in such matters. If they were in agreement on the really important things, minor differences of opinion could be passed over easily enough, but they seldom are of the same opinion as to what is really important. One, for example, will lay out a pumping station on pretty nearly the lines of a Gothic chapel, suppress all useful window spaces and take his chances on the convenience of the plant in operation. The other will make the structure about as decorative as a soap factory and subordinate everything to the exigencies of equipment. It sometimes seems as if such differences were irreconcilable and one really had an entity composed wholly of two unsupported ends. Now, from the point of view of the ordinary man, both extremes involve gross inconsistencies. Gothic chapels as such do not have smokestacks, nor are soap factories customarily public buildings placed in conspicuous positions. As with the exterior, so with the interior. One man will fill it up with tiles and lacquered brass and the other with cement and cast iron, and so it goes. The practical value of the decorative is the real moot point, and that is as old as architecture and engineering.

One thing often lost sight of is that many elements now chiefly decorative were once purposeful, and that in losing their purpose they have lost their chief artistic interest, so that their use is now merely stupidly imitative. It is the common fault of the unpractical tacitly to assume artistic canons that are two or three hundred years out of date, so far as the reasons for their origin are concerned. Methods and materials for structures have changed very rapidly during the last century and the purposeful and appropriate, which is really the artistic, has changed with them. The pointed arch may or may not be beautiful in itself, but it certainly has no structural appropriateness in a modern steel building. Engineering structures of all kinds must first of all be completely adapted to their purposes, which are primarily utilitarian. To take the pumping station as an example, its first duty is to pump water with the greatest possible reliability and economy. All the working parts should therefore be arranged with these points in view, providing for all the contingencies of practical operation. Then and not until then is one justified in going after the decorative. The building is merely the outer casing of the machine from this standpoint and the sole qualification is that it must in no wise lessen the efficiency of the working parts. From the civic standpoint the externals must be harmonious with their environment and with this in view such elaboration is justified as the judgment of the civic authorities may agree to. Likewise, as to the interior there is no objection to elaborate finish that does not interfere with operative features. The same general principles hold for works of any sort built by private enterprise. The thing always to be remembered is that such things should begin from the utilitarian end, and that unless they are suitable from this standpoint decorative features give them no claim to consideration whatever.

A case that comes to mind is that of two libraries in large cities. One of them is conspicuously good in architecture and decoration, but the distance from the delivery room to the nearest part of the stack is greater than from the delivery room to the very farthest corner of the stack in the other, much plainer building. The first as a building is admirable, but as a library building it is inefficiently designed. Our American engineering structures vary commonly in going to one extreme or the other, and it would be a capital thing if architects and constructors could study some of the recent European designs for power plants of various sorts. It has been pretty effectively demonstrated abroad that even a smokestack need not necessarily be ugly and that buildings for the most grimly utilitarian purposes may be made altogether inoffensive and even decorative without considerable increase of cost. So as to the interior fittings, there is a tendency toward overdoing things on the one hand, or toward carelessness on the other. Some engineers delight in expensive finish, as did the old-time locomotive constructors. They build very striking but needlessly expensive plants, while others save a comparatively small amount at a great sacrifice of appearances. The fundamentals inside a plant are good light and cleanliness and the fittings should be planned with respect to these points. The strongest reason for some elaboration is its usefulness in enforcing cleanliness, and some expense here is really justified on utilitarian grounds alone. The idea of a judicious balance between cost and outer appearances is one that deserves study. The utilitarian purpose on various engineering works must be kept to the front, however, and the architect should be called upon not to design a building into which the working plant may be put, but to house the latter, after it is designed, in a dignified and appropriate manner, and experience has certainly shown that this can be accomplished. After all, there is much to be said for the Socratic view that beauty involves complete adaptability to use.

Handling Electrically Driven Valves.

In power plants where the principal steam valves are operated by electric motors it is important that the system should be flexible in order to provide the proper degree of protection in case of emergency, but on the other hand, the manipulation of remote control valve switches by inexperienced or unauthorized persons should be carefully guarded against. To some degree these requirements are antagonistic, and in each plant a careful study should be made of the operating conditions before the installation of the valve motors and their circuits. At the Market street station of the New Orleans Railway & Light Co., described in this journal on Dec. 7, 1907, to take a concrete case, all important steam and exhaust valves are electrically driven, the principal controlling switches being mounted on a horizontal wall panel in the engine room. Each switch is numbered and is provided for two-way throwing, one position closing the corresponding valve and the other opening it. Induction motors operated at 220 volts three phase without starting resistances are attached to the valves by gearing. A responsible engineer on each shift is provided with a diagram showing the valve numbers and piping in skeleton form. It has not been thought best to attach this diagram to the switches, on account of the possible interference of unauthorized persons, and as the station is one of large size, with carefully defined responsibilities, it is reasonable to assume that the course followed best meets the local conditions. In case of trouble it is a matter of a very few seconds to bring the responsible man to the front, and such a man is obviously the best fitted to handle emergency conditions.

Small plants operated by less highly organized shifts can be allowed a wider latitude with safety. The value of the machinery at stake is not so large, and the fitness of each man in the station to handle emergencies in a broad rather than a specialized way is, on the whole, more probable. There is often considerable looseness in regard to admitting strangers within small plants, however, and for this reason it is certainly a wise precaution to provide the valve switches with some form of lock which can only be operated by the station employees. The skeleton piping diagram and numbered valves are a convenience in all such cases, and may profitably be supplied to each man on duty or else posted near the switches.

It is desirable to operate the motors of all electrically controlled valves in daily service and to test those not in use at least weekly. The induction motor is so reliable that ordinarily there is little danger of its being out of commission when wanted, but the test serves the two-fold purpose of ascertaining the existing conditions and encouraging regular inspections. The use of pilot lamps in connection with motor-operated valves is an advantage, especially in cases where there are a large number of switches and pipes involved. If this is not done the switches should as a rule be carefully labelled for the open and closed position of their respective valves. It should never be forgotten that the careless closing of the wrong motor circuit may cause a costly burn-out, and if rules for the operation of the station are promulgated, the valve question should be treated with the utmost clearness as to responsibilities.

The Ageing of Mild Steel.

The results of some interesting testing experiences in mild steel are given by Mr. C. E. Stromeyer, of Manchester, England, in a paper read before the Iron and Steel Institute, at Vienna, last September. The term "ageing" used in connection with the results of his tests may be a little misleading. It might mean fatigue or some change in the physical or other constitution of the steel, taking place with the lapse of time. Inasmuch as the experimental investigation covered by this paper does not include the continuously repeated application of loads to test specimens, the "ageing" must relate to the latter of the two interpretations of the term. It is unfortunate that results of chemical analysis could not have been given with the results of the physical tests. Although the metal is described as mild steel, it is essentially impossible to make a satisfactory interpretation of some features of the experimental results without knowing the percentages of such elements as phosphorus and sulphur, or even carbon.

The tests include one set of plate samples with sheared edges, held for nine weeks in their natural condition, then stored for twenty-three weeks in ice at a temperature of —16° Fahr., after which they were bent by a sledge hammer until they cracked. Another set of similar samples with sheared edges, after lying for thirty-two weeks in a storeroom were bent in the same manner at ordinary temperature. Four other sets of samples, after being annealed, planed on their edges and nicked on their edges, were also bent until the nicks cracked; one lot having been bent immediately after nicking, one after waiting twelve weeks, and another lot after having waited thirty-two weeks. Five other sets were annealed, planed and nicked on their edges; some of these were bent at once and others after boiling for fifteen minutes, and others again after remaining seventeen weeks in the steam space of a Lancashire boiler under a working pressure of 120 lb. per square inch; and others finally after either being held in their natural condition seventeen weeks or for a short time in a cold chamber.

The operation of bending to which these test specimens, each about 0.43 in. thick, was subjected resulted in failure by cracking. The inner radii of curvature, the stretch or elongation on the outer surfaces of the curves, the character of fractures, whether silky or crystalline, and other physical features of the fractured test pieces, were carefully observed or measured. Drop tests were also made by Prof. W. K. Hatt, of Purdue University, to disclose as far as practicable the capacity of the metal to resist rupture by impact.

Reviewing the elongations on the outer surfaces of the curved plates, Mr. Stromeyer concludes that "the ageing process is accelerated by exposure to heat" and that fifteen minutes' boiling has about the same effect as seventeen weeks steaming in the Lancashire boiler. It is not to be understood, however, that the results are uniform as to these points. In fact, as would be expected, there is far from uniformity in them. Again, commenting on the effect of freezing test pieces for a period of seventeen weeks, the author states that with the exception of three samples only, "the average of the other tests" shows "that the frozen samples have preserved 30 per cent. more elongation than the stored ones, and 50 per cent. more than the boiled ones, the means of the respective elongations being 24 (original), 12 (stored), 8 (boiled) and 16 (frozen) per cent. It is thus evident that cold storage does less harm to mild steel than steaming. . . ."

The test of samples by bending without the removal of sheared edges immediately after shearing, twelve weeks after shearing and thirty-two weeks after shearing was "a great disappointment" as disclosing nothing satisfactory. "Equally indefinite are the bendings of the frozen samples . . . which had been stored in ice for thirty-two weeks, . . . ," although the fractures showed the frozen steel to be a little more brittle than the warm metal, in accordance with the common impression. This opposes to some extent the conclusion stated above that the samples stored in ice showed more elongation than the others.

The contradictory character of some of these results or at least their failure to justify any positive conclusions is shown by the statement of the author "that there is nothing in these experiments to show whether mild steel is more or less brittle when cold than hot, . . ." He recognizes the fact that railway rails snap more frequently in cold weather than in warm, but whether this is due to the more rigid frozen roadbed of the winter season, or not, he does not attempt to state.

The author makes certain deductions from these tests which are rather disappointing. He states that "bending tests of samples with sheared edges seem to be of no scientific value, . . . ;" also that "bending tests of samples with planed edges are even less useful; at least, under these conditions all the 7/16-in. plates bent double equally well." He places more value, however, on bending tests of samples having planed and nicked edges, the nicking appearing to work considerable injury to the plate by making a failure liable to begin there, i. e., nicking appears to induce some local brittleness. It may be doubted whether the author is really justified in stating that the amount of phosphorus in the metal seems to be of no importance in this connection. It is, of course, well known that phosphorus is a prejudicial hardener and there are probably few experienced engineers in the working of steel who would not prefer a low phosphorus content to a high one where there is to be any treatment of cold plates like that of calking.

It is a long time since any extended experimental investigation has been made as to the effects of such shop manipulations as punching, shearing, nicking, or others of a similar character, and it is somewhat disappointing to find so little added to our real knowledge of this subject by a paper of this character. The experimental results which it contains are certainly interesting and they must necessarily add a little to the general data bearing upon this whole subject. It would not be difficult to explain what little needs explanation in it by what has been known for many years regarding the effect of punching and shearing on the metal in the immediate vicinity of the surface of separation. The creating of fine cracks in the zone of injured metal and the gradual extension of some of them may easily account for any of the "ageing" effects considered; nor is the possible effect of such nicking as that done in this case wholly an unknown quantity. It is to be hoped that Mr. Stromeyer may in the future extend his investigations so as to include not only the fatigue tests contemplated, but also chemical analyses of the steels employed.

The Control of the Septic Tank Process.

Elsewhere in this issue there is given the full text of the most important decision yet made by a court of final jurisdiction in this country concerning sewage disposal. It completely upholds the patent claims of Donald Cameron and others to the septic process of treating sewage. Not since the time when the late Colonel Waring fought to uphold his patents on the separate sewerage system has there been so much controversy concerning an important feature of municipal engineering work. The grounds on which the court reaches this decision are stated so fully in the opinion that it is unnecessary to review them here, but it is profitable to consider the results from three viewpoints; first, the importance of giving publicity to all new advances in engineering work of any sort, whether patented or not; second, the desirability or otherwise of taking out patents on processes and apparatus which will be useful to civil engineers generally; third, the policy which will be followed by the owners of the Cameron patents in the United States.

The Engineering Record has always held that Mr. Cameron introduced and made known the septic tank, as it is used to-day. Years ago, when this paper was known as the "Sanitary Engineer," a description of the Mouras scavenger, the reputed predecessor of the septic tank, was published in this journal, and the apparatus itself received careful consideration by its engineering advisers. This journal has never considered that such appliances were of the same nature as the Cameron septic tank. It has always held, to quote the language of the Court of Appeals, "that Cameron was the first one to subject a flowing current of sewage to the action of anaerobes and aerobes under conditions which secured their separate and successive action, the action of the segregated anaerobes fitting the effluent for subsequent filtration and aerobic action." While it is undeniable that progress had been made by a number of people toward this process and research work had been done establishing certain features of it, the actual complete application of the process, so far as any testimony to date has appeared, seems to this journal to have been made by Mr. Cameron at Exeter. It is possible that somewhere or other a plant may have been based on this septic principle, for a great many different things have been tried in connection with sewage disposal which have never seen the light of publicity. But even if some such hitherto unknown prototype of the septic tank is discovered, the fact must remain that it was Mr. Cameron who made known its importance as a means of sewage treatment. His disposal plant at Exeter was freely opened to visitors and every possible assistance was afforded to them to study what was taking place at every stage of the process. As a result, Exeter became a place of pilgrimage for everybody interested in sewage disposal, and Mr. Cameron was practically acknowledged as the discoverer of a new method of sewage disposal.

It is natural to expect that the decision will bring up again the question of whether an engineer is warranted in patenting an invention. There has never been any question concerning the desirability of patenting mechanical or electrical inventions, except on the part of a very few people, but a feeling has always existed among civil engineers that it was unprofessional to patent their inventions. This feeling is slowly disappearing and The Engineering Record has never understood why it existed so strongly as it has. A large proportion of the designs made by a civil engineer are unpatentable, and others which are patentable are not worth protecting in this way, even from a purely monetary point of view, because the number of their applications is extremely limited. As a general proposition, there is unquestionably the feeling that a civil engineer's duty is to make known any new invention just as promptly as possible in order that it may be utilized by civil engineers everywhere. One reason given for this opinion is that without such publicity somebody may take out a patent covering some design which should not be patented from the point of view of public policy and thus cause more or less annoyance to those who would like to use it. The attempt to collect royalties for a patent on a drop-manhole was responsible in a measure for the general prevalence of this opinion some years ago. On the other hand, there are certain things which an engineer invents that it may be his duty to protect by patents. He may invent a piece of apparatus which will be of general utility and can be readily manufactured and sold as a commercial product. In order to insure that this apparatus is properly made and to make it of the utmost usefulness it must be protected by a patent; otherwise it will be imitated, improperly made and applied for purposes for which it is useless. The engineer may discover some very important process. For it to be successful it is necessary that it should be carried out in carefully designed apparatus and under competent supervision. No chemist who discovers such a process would hesitate for a moment to patent it. In fact, most of the important discoveries in chemistry are made by men whose principal object is to find out improved methods of accomplishing certain ends, which they can patent and thus make useful. If these processes are not patented, they will rarely be taken up commercially but will be neglected or misused. If our patent laws cannot be made to cover such important inventions without offending professional ethics, then there is something distinctly wrong with the whole magnificent patent system which has meant so much to this country's commercial development. The history of the septic tank in the United States shows how unfortunate has been the long delay in reaching a final decision concerning the Cameron patents. It is only necessary to turn to reports of engineers and public officials to see that many septic tanks have been built in the country which are to-day practically worthless, either because they were improperly designed, improperly managed or improperly built. A great deal of admirable research work has been done in connection with sewage disposal by means of septic tanks and there are some disposal works which are operating successfully and furnishing valuable information. This good record has led some people to believe that the design and management of septic tanks are such elementary matters that they can be done by anyone, and as a result a large amount of public money has been absolutely wasted in the construction of works of little or no value. The rigid enforcement of the Cameron patent can prevent anything more of this sort in the future. There are a number of fairly well designed plants which are doing poor work because they are improperly managed. If the owners of the Cameron patents use their legal rights to enforce the proper maintenance of such disposal works, which they probably can do in their negotiations for royalties, they will serve the public well.

Just what the Cameron Septic Tank Co. will do toward enforcing its business rights under the patents thus declared valid remains to be seen. In view of the fact that the stockholders of the company are men of high standing in business, railroad, and public circles, it is only reasonable to assume that their decision will be one which is not only sound from a business point of view but is also characterized by a due appreciation of the necessity of doing nothing to lower the importance of the septic tank in engineering work. It goes without saying that a strong company with a staff of competent technical advisers can accomplish a great deal of good, and earn considerable money at the same time, by preventing the construction of such poor works as are scattered through the Central States, and can also reduce the amount of mismanagement which now characterizes the operation of some of these plants.

Notes and Comments.

The Guatemala Northern Ry., the third transcontinental line south of the United States, was officially opened on Jan. 19, in the presence of Guatemala officials and a delegation from the United States. The first of the roads to cross the southern part of the continent was the Panama Railroad, built a little more than a half century ago. The second line was the Tehuantepec Railway, opened last year, and described in The Engineering Record of Jan. 2, 1907. The completion of the new road is due very largely to the energy of Mr. Minor C. Keith and Sir William Van Horne, who organized the Guatemala Ry. Co., some three or four years ago and took over from the government the operation of the Guatemala Northern Ry. from Puerto Barrios on the Atlantic Coast to El Rancho, a distance of about 134 miles. This road was begun in 1883 and was projected to run to Guatemala City, but work was suspended after 62 miles had been graded and a few miles of track had been laid. In 1892 contracts were made with the late Sylvanus Miller to complete the road to El Rancho. This was done by the end of 1897 but after that date there was a period of operation by lessees during which no new work was done and the property was allowed to deteriorate very much. Under the direction of Mr. Keith and his associates the road has been rebuilt and extended to Guatemala City, where a connection has been made with the Guatemala Central Ry., which was completed between the capital and the Pacific Coast in 1884 by William Nanne, an American. The total length of the line between the Atlantic and Pacific by this route is about 270 miles.

The Board of Water Supply Investigation in New York City has not amounted to anything, according to an official communication to Mayor McClellan by Corporation Counsel Pendleton on Jan. 20. He states that the statute under which the Board acts shows plainly the intention of the legislature to rest very great powers and a wide discretion in the Board, and at the same time to limit strictly the mayor's right of removal of its members to specific cases involving personal wrong-doing on their part. According to the statute, "no member of said Board shall be removed except for incompetency or misconduct, shown after a hearing upon due notice, upon stated charges." Mr. Pendleton states that "misconduct" must be held to mean wilful, conscious wrong-doing, or such gross negligence as will be tantamount to wilful wrong-doing; errors in judgment or the fact that the Board came to an erroneous conclusion as to any matters it was authorized to pass upon, are strictly eliminated by the statute as ground for removal. In this respect there is a very marked distinction between this statute and the provision of the city charter resting absolute power of removal in the mayor, and Mr. Pendleton believes it to be clear that the legislature intended to make this distinction and to limit the right of removal to cases in which the mayor, after a hearing and on formal charges, should judicially find the existence of the specific cases mentioned in the act as a prerequisite to the power of removal. Although there is a difference of opinion as to whether the conclusion of the Board not to award the contract for the Ashokan dam to the lowest bidder was wise, the members of the Board still adhere to their conclusion that the course pursued by them was a proper one. There is no sugestion on behalf of anybody reflecting upon either the integrity or the motives of the members of the Board, and after a very careful consideration of all the circumstances, Mr. Pendleton is of the opinion that, as a matter of law, the evidence and facts brought out at the recent hearing before the Commissioners of Accounts do not warrant the preferment of charges against the members of the Board of Water Supply. This opinion, it is hardly necessary to say, coincides with that of most of the people of New York who have looked into the matter.

The New York Rapid Transit Situation has been materially cleared up in the last few days by the Public Service Commission for New York City. Some two years ago what is known as the Elsberg law was passed providing for a 20-year term of operation with a renewal privilege of not more than 20 years as the life of franchises in rapid transit undertakings in the city. Since that time not a single contract for the operation of subways has been made. On the other hand, the city has found it more and more difficult to borrow money, and is in no condition to build and equip further rapid transit lines without a change in existing conditions. The Public Service Commission has therefore made four recommendations to the Legislature. The first recommendation is the adoption of a constitutional amendment exempting from the 10 per cent. debt limit of the city, bonds for the construction of rapid transit lines, so long as these rapid transit lines shall be self-supporting. The second recommendation is an amendment to the rapid transit law by which leases of extensions of rapid transit lines may be made to terminate at the same time as the original lease. The third recommendation is an amendment to the rapid transit law giving the local authorities and the Commission power to allow the construction and operation of rapid transit lines by private companies upon payment of part of the earnings to the city, or other satisfactory terms, and with a reservation to the city of the privilege of purchasing them at any time after 20 or 25 years without any payment for the franchise itself. The fourth recommendation is an amendment to the same law making it possible for the local authorities and the Commission to let contracts for operation for a longer period than 20 years or else to make the lease terminable at any time after a certain period of not more than 20 years with a provision that the equipment shall be purchased at a fair price by the city at the end of the lease. Inasmuch as it will take some two years to amend the constitution and there is urgent need of improved rapid transit at the earliest possible moment, the thing to do is to amend the existing laws, which were passed at a time of extreme distrust in the management of public service corporations. The demands of a large city for vast sums for police and fire protection, schools, hospitals, streets, water and sewerage works and other necessary features of municipal existence are so great that this journal believes it desirable to have public utilities like rapid transit and public lighting undertaken so far as possible by private capital, provided the rights of the public as well as those of the capitalists are equally safeguarded. It, therefore, believes that it is better for the city to obtain relief by advocating the third and fourth recommendations above mentioned.

THE COMPLETION OF THE LOS ANGELES, CAL., OUTFALL SEWER.

The sewerage system of Los Angeles, Cal., is built on the separate plan, the storm-water runoff being carried directly to the Los Angeles River and other water courses, while the house sewage is conveyed by gravity through a long outfall to the Pacific Ocean. The original outfall sewer, built in 1893-94, extended to the ocean from the existing edge of the city at that time. It was 12.4 miles in length, 5.6 miles of it being of brick masonry and the remaining 6.8 miles of wood-stave pipe, with a diameter of from 36 to 40 in. The location and construction of this outfall rendered the maintenance of the latter especially difficult and expensive. At the same time, the remarkably rapid growth of the city had over-taxed the carrying capacity of the old outfall, so some means of relief was imperatively necessary. The construction of a new outfall was accordingly started under contract in 1904, the location and design being made in such a manner as to avoid the more serious difficulties of maintenance presented by the original outfall.

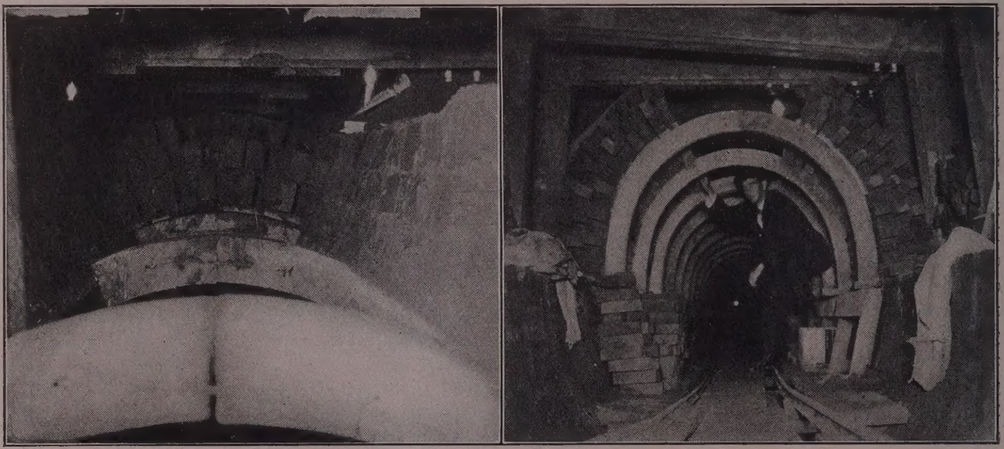
The new outfall has a total length of 65,000 ft., or about 12.2 miles, and is built on a grade varying from 1 ft. in 200 to 1 ft. in 1,100. The cross-section of the sewer varies from a minimum of a 3-ft. 8-in. circle to a maximum 5-ft. by 6-ft. 1-in. oval. The original design contemplated a brick masonry sewer throughout, with the invert lined with Portland cement mortar. Conditions encountered during the construction, however, made desirable the substitution of concrete for brick in the lower half of the sewer barrel where the latter is in tunnel. Concrete manholes were placed at intervals of 500 ft., except on sections in tunnel where they were spaced 900 to 1,000 ft. apart.

The upper 24,250 ft. of the outfall was built in an open cut varying from 5 or 6 ft. to 25 ft. in depth. The next 10,752 ft. extends through a hill which rises to a maximum height of about 100 ft. above the sewer invert, and in this section the outfall was built entirely in tunnel. Beyond this tunnel is a deep cut about 2,000 ft .in length, followed by a series of cuts and fills for nearly a mile. The remainder of the outfall, embracing approximately 4.5 miles, was built in open cut, with the exception of two tunnels, one of which is 913 ft. and the other 1,281 ft. in length. The invert at the end of the last tunnel is 58.9 ft. above mean high tide in the ocean and is only 622 ft. inland from the high-water line on the shore. The flow in the outfall is carried down this hill to the ocean in a 24-in. cast-iron pipe laid to a steep grade. This cast-iron pipe terminates near the high-water line on the shore in a 30-in. riveted-steel pipe, which continues 800 ft. off-shore on a pile trestle.

After the construction of the outfall had been in progress under contract for two years the contract was abandoned in August, 1906, owing chiefly to difficulties encountered in driving the long tunnel. Up to that time about 60 per cent. of the open trench work had been completed; 3,380 ft. of sewer in the main tunnel had been built from the lower portal and 500 ft. more of the tunnel had been drifted and timbered beyond the end of the finished section. After a delay of some three months the completion of the construction was undertaken by the city with its own forces under the supervision of Mr. Homer Hamlin, city engineer. Notwithstanding the unusual difficulties presented, the outfall was finished and placed in service in November, 1907.

The soil conditions existing in the hill through which the long tunnel had to be driven were particularly adverse. The surface of the ground is at an average height of about 70 ft. above the sewer invert for almost the entire length of the tunnel. The ground is made up of quite distinct strata of clay, sand and gravel, these strata having little regularity of depth below the surface. Ground water was not encountered in the construction of the portion of the sewer completed when the work was undertaken by the city. At the end of the 500 ft. of tunnel that had been drifted and timbered at that time a well-defined vertical stratum of impervious clay, some 20 ft. thick, formed a natural dam, back of which was one of the large separate underground reservoirs common to the region in the vicinity of Los Angeles. This reservoir was in a stratum of water-bearing sand and gravel, with the water plane varying from 114 to 118 ft. above sea level, while the invert of the sewer in the tunnel dropped from about 106 ft. at the upper end of the tunnel to 100 ft. above sea level at the lower end.

The construction of the portion of the tunnel built prior to the inception of the municipal work was handled principally through shafts sunk from the ground surface at intervals of about 500 ft. The last of these shafts to be sunk by the contractors was at the end of the partially-finished 500-ft. section of the tunnel, and penetrated the natural clay dam forming the limits of the underground reservoir. As a result of this pentration water entered the tunnel in large quantities and the ground around the shaft sank badly. When operations were started by the forces of the city the excavation had not been carried ahead of this shaft.


Two Views of Tunnel Arch under Construction.

Before active construction was commenced by the city's forces somewhat extensive investigations were conducted to determine the scope and character of the underground reservoir. Five construction shafts had already been carried down to the ground-water level in advance of the tunnel heading. From these shafts and from a well driven about 100 ft. in advance of the shaft at the end of the partially-finished 500-ft. section the location of the ground-water level was determined to be well above the floor of the tunnel at the elevation already stated. Meanwhile, an air-lift pumping installation was placed in the driven well and one in the shaft adjacent to it. A motor-driven duplex air compressor with a capacity of 750 cu. ft. of free air per minute was also installed to furnish power to operate the two air-lifts. The latter were then driven continuously for three weeks, and during that time delivered about 9 cu. ft. of water per second. From the results thus obtained the conclusion was reached that the ground-water level could be lowered sufficiently at a reasonable cost by pumping to permit the completion of the tunnel. It was also believed that the sewer could be finished by January 1, 1908. Operations were accordingly started immediately, although delays due to various causes had brought the time of starting up to December, 1906. The entire outfall, including the tunnel, was then finished in eleven months.

As the ground-water level could be kept lowered only by continuous pumping, and since the completion of the outfall at an early date was quite imperative, the decision was made to prosecute the construction day and night with three 8-hr. shifts and with as large a force as could be used to the best advantage. Eighteen construction shafts were sunk from the surface to the site of the tunnel during the progress of the work on the 6,850 ft. of tunnel built by the city. These shafts were spaced 450 to 1,000 ft. apart, depending on conditions, and were 6 x 8-ft. in cross section. The soil conditions were such that the shafts were generally lined from the top to the bottom with 8 x 10-in. timbers. The material excavated from the tunnel was raised to the surface and the timber for lining the tunnel was lowered by means of horse-driven whims, as many as twelve such whims being in service at the same time. Elevator hoists were installed in the shafts to lower the material for building the sewer barrel. Four of these hoists, two motor-driven and two driven by gasoline engines, were provided, so operations could be in progress on the masonry at four other shafts simultaneously with the tunneling and timbering.

The air-lift pumping installation first provided by the city was later augmented by the addition of two smaller motor-driven compressors, with a combined capacity of 750 cu. ft. of free air per minute. The three compressors were later all placed in a central plant about midway on the work in progress. An air line was then carried to the adjacent shafts on each side of the plant. Connections were made at these shafts to a 12-in. driven well in each of them, so water could be pumped from a depth of 25 ft. below the tunnel grade. A 5-in. discharge pipe was placed inside of the well casing to carry the water to the surface, or to the level of the tunnel, the air-supply line being placed in the casing, between the latter and the discharge pipe.

Four Byron Jackson vertical centrifugal pumps in 4-in. and 6-in. sizes were also installed in the shafts beyond the range of the air-lift plant. Each pump shaft was belted to an electric motor on the surface, the shafts being 40 to 70 ft. in length. The pumps took suction from a sump below the grade of the tunnel until the masonry was completed adjacent to them and they were of no further use.

At one time five air-lifts and four of the centrifugal pumps had to be kept in operation to hold the ground-water level below the grade of the tunnel. The combined output of the water under these conditions was 9 cu. ft. per second. Part of this water was pumped to the surface and carried to water-courses in flumes, while the remainder was discharged through the portion of the tunnel already opened. When the pumps were kept running continuously in this manner the ground-water level could be held below the grade of the tunnel, but at any cessation in their operation the water level would rise rapidly. In spite of the hazardous condition thus presented the tunnel work was prosecuted without interruption. It was also finished without injury to any of the employes, except one man who was killed by falling into a shaft, due to carelessness.

Shoring in 500-Foot Rebuilt Section.

Pump House and Hoist at a Shaft.

The tunnel excavation was made 6 ft. 8 in. wide at the top, 8 ft. 4 in. wide at the bottom and 7½ ft. high in the clear inside the timbering. The latter had to be placed directly as the tunnel heading advanced, owing to the character of the soil. Experience in the portion of the tunnel previously completed showed conclusively that only heavy timbering could be used safely. Accordingly, bents consisting of an 8 x 10-in. by 7-ft. 11¾-in. batter post on each side, with an 8 x 10-in. by 8-ft. cap between these posts, were placed 4 ft. apart on centers. Part of the load on the cap was carried to the posts by a 6 x 6-in. by 3-ft. knee-brace on each side. The posts were attached at the bottom to a 2 x 12-in. sill extending across the tunnel, and a 1 x 8-in. plank was placed between the feet of the posts to prevent the latter being pushed inward. The top and sides of the excavation were sheeted with 2 x 12-in. lagging laid against the bents. The mining work at the tunnel heading was done by four men, a miner and his assistant, a shoveler loading cars, and a laborer pushing the cars to the foot of the shaft. The sheeting was driven by hand in advance of the excavation and was guided by a false bent 2 ft. in advance of the last regular one in place. When the worst conditions were encountered temporary bulkheads were also placed across the lower part of the heading until the sheeting could be driven and the excavation completed at the top.

The cars in which the excavated material was hauled to the shafts and hoisted to the surface by the elevators were specially designed to operate in the limited space available. The car body had a capacity of 0.5 cu. yd. and was on a low four-wheel truck running on an 18-in. gauge track. The rails of the track were carried by a pair of 2 x 4-in. wooden sleepers suspended longitudinally in the tunnel from the timbering by a piece of ¼ x 1¼-in. bar iron to each bent. Each of these bars of iron was bent as a stirrup, made wide enough to extend across the tunnel so the ends could be fastened to the posts of the bent about two-thirds the way up. The stirrups were also bent about 2 ft. from both ends in such manner that the middle section of each of them would come horizontally just below the springing lines of the arch of the sewer barrel. This horizontal middle section was long enough to permit the two 2 x 4-in. sleepers to be placed on it, longitudinally with the tunnel, at the gauge of the track. With the track thus suspended the space above it was free of braces, so the cars in which the excavated material was removed and the timbering delivered could be operated readily. At the same time, the track and the stirrups on which it was suspended were high enough to permit the lower half of the sewer barrel to be constructed without interference in any way. Earlier in the progress of the work the track was suspended from the caps of the bents by vertical wooden braces, but these braces were found to interfere with the laborer pushing the cars.

The original plans for the outfall contemplated that the entire barrel of the sewer within the tunnel should be built of three rings of brick laid in cement mortar. In order, however, to provide a more substantial base for the sewer barrel on the uncertain foundation offered by the poor soil, the invert was built of concrete up to the springing lines of the arch, and lined with a single ring of brick. The concrete was carried out on the sides to the inner edge of the posts of the bents of the timbering, thus forming a broad base for the footing.

The only forms required on the exterior of the masonry in building the invert was a row of sheeting along each side of the tunnel, which sheeting was placed against the bents of the timbering. This sheeting was set in advance of the concrete work and was carried up to the top of the concrete only. The space between it and the outside sheeting was filled with material excavated from the base of the tunnel in order to permit the masonry to be laid at the required depth, as the sills of the bents were placed 8 in. above the sub-grade.

As the upper part of the timbering may fail unequally the three-ring brick arch of the sewer barrel had to be built so the space between it and the sides and the top of the tunnel could be well backfilled. Special forms for the arch were therefore designed, which forms permitted the sequence of operations necessary to allow the backfilling to be placed without interfering with the progress, or adding to the cost of the work. When the invert had been completed the suspended track was removed, and another track laid on 4x4-in. cross timbers on the invert. The length of these cross timbers was made such that the lower edge of the timbers was 6 in. above the invert at the center, thus providing a space of 140 sq. in. in cross section below them in which the discharge from the pumps could flow to the shafts.

The details of the special forms used in building the brick arch are shown in an accompanying illustration. The forms were built in sections 7 ft. 2 in. long, and each section was divided longitudinally at the center line into two parts. Each 7-ft. 2-in. section had three 2x4-in. ribs. These ribs each rested at the lower end on wedges on a 2x4-in. upright carried by the 4x4-in. timbers. The two halves of each rib were fastened together at the top by a long hook of ⅜-in. iron. The ribs were lagged on both sides up to an angle of about 30 deg. from the horizontal with 1½x3-in. pieces, planed to the curve of the intrados of the arch. These lagging pieces were nailed to the ribs and were also fastened to the latter by a 2-in. strip of steel plate attached at the top and bottom by two ¼-in. bolts. Above this fixed lagging on both sides of the form the remainder of the lagging was placed as the arch was built.

The forms were set in place and the brick laid up to the top of the fixed lagging by the masons, who could readily reach down over the lagging to the springing line of the arch. Then as the work advanced above the fixed lagging loose pieces of 1½x3-in. planed lagging in lengths the same as that of the form sections were laid on the ribs as required. This loose lagging was carried up on both sides to within about 1 ft. of the vertical axis of the sewer barrel, leaving a keystone 2 ft. wide to be built later. The backfilling between the arch and the timbering could thus be placed in such manner as to insure that the space was entirely filled. The arch was built up to the keystone on both sides and backfilled during one night shift. The keystone was then finished during the next shift by the best mason available.

In order that the brickwork of the keystone could be laid in short sections, thus permitting the space above it to be backfilled, the ribs of the forms were lagged with 12x2x4-in. blocks made to the proper curve. The ends of the sections of block lagging were carried by two horizontal 2x4-in. pieces between the ribs, one of these brackets being placed on each side of the opening at the top of the loose lagging. With this arrangement of block lagging a mason could carry the brickwork of the key of the arch ahead rapidly and easily, and the backfilling over the crown of the arch could be done most satisfactorily.

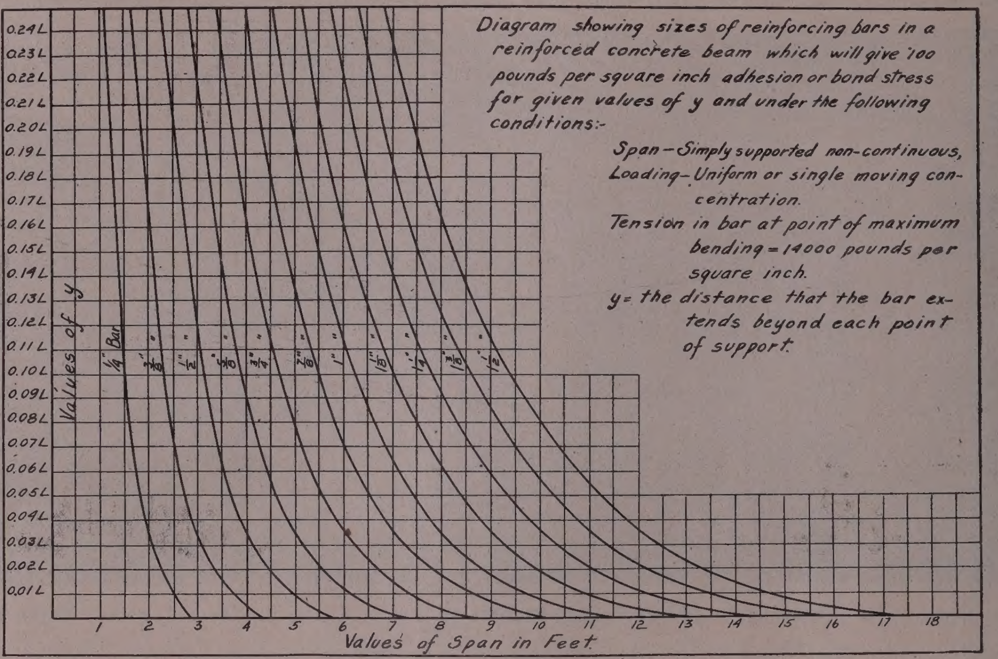
After the forces had been organized and the plant installed a regular sequence of operations was generally followed. Mining was carried in both directions from the base of one shaft. As soon as the tunneling had been finished about half-way toward the shafts on both sides of the one from which it was in progress, the miners were moved ahead to the next shaft, and invert construction was then carried ahead both ways from the first shart to about the half-way points between shafts; the work on the arch then followed in both directions from the base of the first shaft. In this manner the tunneling, concrete work on the invert and brick laying on the arch could be in progress simultaneously without interference, the hoist in each shaft being used to handle only one class of material. Several sections of tunneling, invert construction and arch work were also being prosecuted at the same time in this manner.

The 500 ft. of partially-finished tunnel that was driven before construction was undertaken by the city was completed by the latter under serious difficulties. The tunnel in this 500 ft. had been excavated and timbered. The timbering had bents with a 6x8-in. batter post on each side and a 6x8-in. cap; the bents were placed 4 ft. apart on centers, the clear span of the caps being about 6.5 ft. and the clear width at the base of the bent 8 ft. The space between the bents were sheeted with 2x8-in. lagging. The caps of these bents had cracked badly with the load on the timbering, so each cap had been reinforced with two vertical posts spaced across the tunnel. These posts practically blocked the cross section of the tunnel, as far as construction of the sewer barrel was concerned, but the caps were in such shape that they could not be left unsupported. During the previous tunneling work the grade had also been lost in some manner, with the result that the bottom of the tunnel was as much as 3.5 ft. above the required grade. Notwithstanding these conditions, the excavation necessary to rectify the grade in this 500-ft. section was made and the sewer barrel built without an accident.

The work in this section was handled in short lengths to avoid any danger of the collapse of the timbering. The vertical posts under three adjacent bents were replaced by two 15-in. 60-lb. I-beams, both carried at each end by a 12x12-in. timber post, the space between the pair of posts at each end thus being left free for construction. The I-beams and timbers were also spaced 4 ft. apart to provide room for a construction track and cars between the posts. The bases of the latter were carried down below the grade of the tunnel and seated on a base of two 24x24-in. pieces of 2-in. plank. The material above the grade of the tunnel was then removed and the invert and arch of the sewer barrel built in short sections between the timbers carrying the I-beams. The latter were next blocked up on the finished work, and the timbers removed so the closing sections of the sewer barrel could be built. All of this work was handled in such manner that the space between the sewer barrel and the timbering could be entirely backfilled with sand.

Openings necessarily had to be left in the invert of the sewer at each shaft to permit the pipes of the air lifts and centrifugal pumps to be carried to the surface, or the water from them turned into the sewer invert until the sewer was finished. The openings could not be closed, however, until the pumping could be stopped. In order that the closure of the openings might be effected readily, the casing of each air-lift was cut 2 ft. 10 in. below the flow line of the sewer and removed. A coupling, threaded on both sides, was placed over the discharge pipe so the top of it came just below the sewer invert. Then, when water could be turned through the tunnel the portion of the discharge pipe above the latter was removed, and on the cessation of pumping a cap was screwed on the coupling to close the pipe and the opening in the invert was filled with concrete.

The concrete manholes in the tunnel section of the outfall were built in the construction shafts, the sewer barrel being reinforced to carry them. These manholes are 5 ft. in diameter and from 60 to 90 ft. deep. Their construction was simplified by a set of forms built specially for the purpose. These forms were in sections 4 ft. long, each section being divided longitudinally into four parts, each part being one-quarter of the enclosed circle. The ribs of the forms were each made of three pieces of 1x4-in. spruce and were spaced 2 ft. apart on centers. The lagging was 2x3-in. lumber, cut on radial lines and planed on the outside to the curve of the manhole. Each part of the section was wedged in place against the adjacent parts of the same section so the interior of the forms was free of braces. The bottom section of the forms rested on the sewer barrel, and each succeeding section on the one below, until a height of 20 ft. was reached. At this point four 5/8x4x15-in. steel plates were inserted in the concrete, each plate being half-way between the vertical joints in the forms. These plates were set so their ends projected enough on the inside of the concrete to permit the ribs of the forms to rest on them, and were sufficiently strong to carry the forms to a height of 20 ft., where a second set of them was placed. With this arrangement the section of forms below could be removed and used above again in the same manhole. The one set of forms was also used in building all of the deep manholes. The latter built in this manner are perfectly vertical and are true in cross-section.



Relation between Size of Reinforcing Bars and Unit Adhesion.

The deep trench work on the outfall above the long tunnel all had to be sheeted to hold the sides until the sewer could be built. The sheeting consisted of 2x8-in. plank and was driven with a steam hammer carried by a traveler spanning the trench. The hammer was suspended on a truck carried by a crane runway, so it could be used on both sides of the trench. This outfit greatly facilitated the progress of the work. The excavation in the deeper trench sections was made down to the ground-water line with a drag scoop-bucket excavator on a traveling derrick operating ahead of the trench. Below the ground-water level the material was removed in buckets, also handled by a traveling derrick.

The outfall crosses two depressions just below the long tunnel, in which the natural surface was from 8 to 16 ft. below the grade of the base of the sewer barrel. One of these depressions is about 600 ft. wide, and both of them were filled up to the sewer at the crossing, the original intention being to carry the sewer on these fills. The soil of which the fills were made has little or no stability when wet, however, so the sewer was built on two longitudinal concrete walls carried down 2 ft. below the natural ground surface. The lower half of the sewer barrel at these crossings was built of concrete, properly reinforced, the base being 8 ft. wide, while the walls were spaced 7 ft. apart on centers. The longitudinal walls are braced together at intervals of 16 ft. by 6-in. cross walls. The longitudinal walls are also reinforced with 3/4-in. horizontal rods spaced 2 ft. apart, and the cross walls with 5/8-in. rods spaced the same distance, the ends of the rods in the cross walls extending into the longitudinal walls. The walls were all built in trenches after the fills had been made, as the modification of plans was not made until then. These trenches were backfilled, but no dependence is placed on the fills to carry the sewer, although the portion of the fill confined by the walls lends considerable strength to the footing formed by the walls.

The construction of the outfall sewer as carried on by the city was completed under the immediate direction of Mr. Homer Hamlin, city engineer of Los Angeles, who personally supervised the work. Mr. E. A. Tuttle was the principal assistant engineer during the design and construction. Mr. A. C. Hansen was in direct supervision of the construction forces.

Electric Heaters were recently put to a novel use for a shrink fit of a crank pin into a crank disc on a 500-h.-p. cross-compound Russell engine. In replacing the old pin, a new pin, 6 in. in diameter, with a taper of 1/8 in., was to be fitted into the crank disc 5 in. thick. Owing to the undesirability of expanding the disc with blow torches, a number of heating units from General Electric 6-lb. electric flat irons were grouped around an iron core and inserted into the 6-in. crank pin hole and sufficient current passed through the units to maintain them at white heat. After the heaters had been operated at this temperature for 4 hr., the disc had expanded sufficiently to allow the crank pin to slip in place. An interesting feature of the work was that the flat iron heaters were not injured.

The Influence of Bond on Size of Reinforcement Bars for Concrete.

By Wm. P. Creager.

The design of a reinforced concrete-beam progresses by various stages, according to the ideas of the designer, until the percentage of metal in the tension side has been determined. At this point the question arises, what size and shape of bar to use? In this connection the question of bond is of the most importance. A discussion of the relative merits and demerits of plain bars as compared with deformed bars will not be attempted here. It is merely a question of how much one can afford to pay for mechanical bond where, in an otherwise well-balanced structure, plain adhesion is deficient. It is apparent that, no matter how low the working intensity of adhesive or bond stress may be, the actual intensity of stress will never exceed this amount, provided a large number of bars of sufficiently small size are used. As a matter of fact there are but four methods used to transmit the stress from the bar to the concrete.

1. Plain bars, depending solely upon adhesion of steel to concrete.
2. Plain bars, depending upon adhesion and one or more anchorages at isolated points, such as end anchorages and rigidly attached stirrups.
3. Deformed bars, depending upon adhesion and numerous anchorages very close together.
4. Deformed bars with additional anchorages at one or more points.

The relative advantages of the foregoing methods have led to an endless array of arguments. It is hard for the writer to see how one can, generally speaking, advocate one method to the exclusion of all the rest. So much depends upon existing conditions, the type of design, its relative importance, and other things, that each case has an individuality of its own. Sometimes the preponderance of some particular detail will cause the adoption of a certain class of bar for the entire work.

It is, of course, advantageous to use as few bars of large size as is consistent with the unit bond or adhesive stress in the type of bar chosen. Not only is this necessary on the ground of economy in placing the reinforcement, but also owing to the relatively greater pound-price of small bars over those of the basic size. The tendency in this direction has, however, often led to the use of bars of such size as to materially weaken the structure through defective adhesion of the steel to the concrete.

It is the object of this paper to provide a rational method of determining the maximum size of bar that can be used in any given span and system of loading, consistent with the adopted working intensity of adhesion or bond stress in the bar. It is found that such a rational method can only be applied to those spans in which the reinforcing bars lie wholly in the bottom surface, for when some of the bars are trussed up to resist shear, all the tension is confined to those bars which are left straight, thus increasing the bond or adhesive stress according to the arrangement of the bars. This method of resisting shear should be used with care and never attempted unless the size of bar is sufficiently small to reduce the actual intensity of bond or adhesive stress to an amount much below that ordinarily used for that type of bar. Where isolated anchorages are used it is probably best to be guided by experience, increasing the working intensity of bond or adhesive stress in proportion to the efficiency of the anchorages.

In all of the following the tension of the concrete is neglected and the position of the neutral axis is assumed to remain the same for all working conditions.

Let l be the span of a simply supported non-continuous beam, in inches,
w be the uniform load carried by the beam in pounds per linear inch.
W be a single concentration in pounds.
x be the distance from any point in the beam to the nearest point of support in inches,
M be the maximum internal or external bending moment in the beam in inch-pounds,
M' be the corresponding bending moment at any point x inches from the nearest point of support,
S be the maximum intensity of tension in the bar in pounds per square inch,
S' be the corresponding intensity of tension at any point x inches from the nearest point of support,
d be the side or diameter of the bar in inches,
y be the distance in inches that the reinforcement extends beyond the point of support,
F be the intensity of bond or adhesive stress in the bar in pounds per square inch.

First.—The investigation of the case of a single moving concentration. The maximum bending occurs when the concentration is at the center of the span or, $M = W\,l \div 4$.

At any position of the load x inches from the nearest point of support, $M' = Wx\,(1 - x/l)$.

Since the tension in the bar at any point is directly proportional to the bending moment at that point,

$$\frac{S'}{S} = \frac{Wx\,(1 - x/l)}{\tfrac{1}{4}\,Wl}$$

whence,

$$S' = 4\,x\,S\,(1 - x/l) \div l \qquad \ldots\ldots(1)$$

In order for the beam to fail at any point through defective adhesion or bond, it is necessary for the tension in the bar at that point to overcome all the adhesion or bond developed over an area equal to the perimeter of the bar multiplied by the length of the bar between the point in question and the end of the bar. Since the maximum tension in the bar at any point occurs when the concentration is located at that point, it follows that the total bond or adhesive stress between any position of the load and the end of the bar must equal the total tensile stress in the bar at the point of loading.

Therefore, for a square bar, $S'\,d^2 = 4\,d\,F\,(x + y)$ and for a round bar, $\tfrac{1}{4}\,S'\,\pi\,d^2 = \pi\,d\,F\,(x + y)$ From either of the above there results,

$$S' = 4\,F\,(x + y) \div d$$

Substitute this value of S' in equation (1), solve for F and there results,

$$F = \frac{S\,x\,d\,(1 - x/l)}{l\,(x + y)} \qquad (2)$$

Differentiating,

$$\frac{\delta F}{\delta x} = \frac{\left(d\,S - \dfrac{2\,d\,x\,S}{l}\right)(x + y) - d\,x\,S + \dfrac{d\,x^2\,S}{l}}{l\,(x^2 + 2\,x\,y + y^2)}$$

For a maximum,

$$\left(d\,S - \frac{2\,d\,x\,S}{l}\right)(x + y) - d\,x\,S + \frac{d\,x^2\,S}{l} = 0$$

whence,

$$x = \sqrt{(y^2 + y\,l)} - y \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

Or, for any given value of y, there is a certain value of x which will make F a maximum. For instance, let y equal $l/8$. Substitute $l/8$ for y in equation (3) and it is found that the greatest bond or adhesive stress is developed when x equals $l/4$. Substitute this value of x in equation (2) and there results,

$$d = 2\,F\,l/S \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

From an inspection of equation (4) it is found that, in a simply supported non-continuous beam, for the system of loading in question and any value of y and working stresses F and S, d is directly proportional to the span.

The diagram is plotted from equations (2) and (3). Along the bottom are found values of l; on the left are found values of y and the several curved lines represent values of d. The following unit working stresses were used:

$$S = 14{,}000;\ F = 100.$$

For example: Suppose we have a beam whose clear span is 72 in. and that the reinforcing bars extend 8 in. on both sides of the points of support. Then y equals $0.11\,l$. If, in the design, the above working stresses have been adopted, it is found from the table that nothing larger than a 1-in. bar can be used.

From equation (4) it is seen that l varies directly as S and inversely as F. Therefore, the values of l in the table can be readily altered to suit values of F and S other than those used above.

Second.—The investigation of the case of a uniform load. The maximum bending moment occurs at the center of the span, or, $M = w\,l^2/8$. At any point in the beam x inches from the nearest point of support, $M' = \tfrac{1}{2}\,w\,x\,(l - x)$. Since the tension in the bar at any point is directly proportional to the bending moment at that point,

$$\frac{S'}{S} = \frac{\tfrac{1}{2}\,w\,x\,(l - x)}{w\,l^2/8}$$

whence,

$$S' = \frac{4\,S\,x}{l}\left(1 - \frac{x}{l}\right)$$

It is seen that this formula is identical with equation (1) and therefore the subsequent discussion in the case of a single moving concentration is also applicable here.

It is seldom that the designer has to deal with other than the foregoing typical cases. For stationary concentrations it is a simple matter to compute the resultant adhesion or bond stress, as the moment diagrams are invariably composed of straight lines. For a complicated system of loading, however, it is not easy to figure closely the maximum size of bar that can be used, and in such cases experience generally rules the choice.

A NEW YORK SHIP CANAL in place of the barge canal now under construction is advocated in the annual report of F. C. Stevens, state superintendent of public works. He advises the legislature to petition Congress to join with the State to make that part of the barge canal project between Lake Ontario and the Hudson River a 20-ft. water-way along the lines suggested by the Deep Water-Ways Commission of 1900. This would accommodate vessels of 8,400 tons while the barge canal has been designed for 1,000-ton boats. This recommendation is without prejudice to the continuance of the work and the completion of the barge canal between Oneida Lake and Buffalo and the completion of the Champlain canal between Troy and Lake Champlain. In accordance with this suggestion a bill has been introduced in both branches of the legislature providing for the appointment of a commission of six members to confer with the federal authorities regarding the proposal. While work has been under way for three years only about one-fifth of it is now under contract.

Cofferdam Excavation for a Power Station.

By C. M. Ripley.

The Economy Light & Power Co. are constructing the foundations for a 10,000-h.-p. hydro-electric plant at the point where the Desplaines River empties into the Kankakee River, the two forming the Illinois River. After the completion of the dam, it is the opinion of the engineers that a full 17-ft. drop will be gained, which, with a flow of 10,000 cu. ft. per second, will be employed for the generation of electric power to be sold mainly in Joliet, Ill.

In August, 1907, J. G. Heyworth, the general contractor, began to move his construction plant by 50-ton barges down the Illinois and Michigan Canal, hauled by a 24-h.-p. Barber Bros. gasoline launch. In a period of three months a camp was built for the accommodation of about 200 men, a 7,000-yd. U-shaped levee, which we will call cofferdam 1, was thrown up, and 5,000 yd. of rock were also excavated from the power plant site and placed in the cribs of cofferdam 2 beyond the levee in the river.

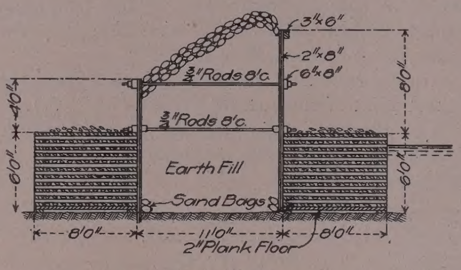
A Lidgerwood 8¼ x 10-in. hoisting engine was mounted at the side of the canal with a derrick for unloading the heavy machinery from the barges. This engine and derrick were also used in connection with the unloading of the barges of crushed stone and a 1-yd. Hayward clamshell bucket unloads three 180-ton barges in 14 hours. All trucking to the job was eliminated in this way. A single-track industrial railway enters the site of the excavation at the northeast corner and is fanned out into eight tracks, on which Western dump cars carry out the excavated material, which is silt, glacial drift and sandstone underlying about nine feet. At the top of a 10 per cent. grade the single track runs level for about 30 feet, at which point an 8¼ x 10-in. Lidgerwood double-drum hoisting engine is located, with the drums facing down the track. Two cables extend down into the excavation and thus one hoisting engine with one engineer attends to the removal of the material and is able to move two trains of six cars up or down the grade at the same time. After the cars get on the level track, horses haul them to the spoil bank.

One of the most interesting features of the work was the way the Page drag scraper excavating bucket was used, both to run the levee around cofferdam 1 and also to assist in filling the cribs in cofferdam 2. In the earlier stages of the work, the two Page buckets with their accompanying engines and derricks, were the first pieces of apparatus to begin excavation. The machines traveled on a track laid just within the limits of the excavation. In one operation dirt was dug, lifted and after the machine made a quarter turn, it was dumped just beyond the excavation limits. Later these machines were run nearer the center of the excavation, and the same 1-yd. special power scraper bucket strung from the 40-ft. boom of the derrick dug out the silt and glacial drift, part dry and part wet, and dropped part into the industrial cars and part in a pile where laborers with wheelbarrows conveyed the dirt to make the earth fill in cofferdam 2, further out in the river. Seven thousand yards of dirt and 5,000 yd. of rock were excavated in a little less than two months and placed either in the spoil bank or in the cofferdam. Thus excavated material from cofferdam 1 was used in the construction of cofferdam 2 as well as making the levee around cofferdam 1.

In the rock excavation, four Ingersoll-Rand 1½-in. steam drills were used, and decidedly heavy blasts were employed during the noon hour and after the end of the day. In that part of the excavation which was beyond the reach of the Page drag bucket, teams and scrapers were used and some pick and shovel work was done.

In the levee which runs at approximately right angles to the Desplaines River for a distance of 120 ft. back from the edge of the stream, 2 x 8-in. plank were driven 3 ft. into the ground, the joints broken and a 3 x 6-in. top waling piece was spiked to it, after which the earth fill was dumped on either side. Entirely different construction was required on the upstream cofferdam where the full force of the 15-mile current is felt and also on the sides where the scouring effect of the stream is most dangerous. Rock cribs are used for both sides of the most exposed parts of the cofferdam. They are 8 x 16 ft. in dimension, 6 ft. deep, with a 2-in. plank floor. They were built of heavy green maple, which almost sank as soon as launched. Three 1¼-in. manila ropes were used to locate each crib in place. A row of 1½-in. holes was drilled just inside the upstream side of the cofferdam. Iron rods were driven into these to further act as an anchor to the cribs and prevent their sliding out of place.

The excavation will be carried down 20 ft. below the average bottom of the river and 24 ft. below the low water level. It will thus be seen that the pumping problem is a very serious one. As yet cofferdam 2 has not been drained since it is hardly completed. The U-shaped levee, however, which forms cofferdam 1, encloses an area of about 50,000 sq. ft., now 14 ft. below the present level of the river. The contractor has hung one No. 3 and one No. 4 Emerson steam pumps from A frames, which have kept the excavation dry. During the drilling for blasting, it frequently happened that springs were tapped, which further complicated the pumping problem. Sometimes one of the pumps had to be operated with part of a strainer exposed above the surface of the water and taking air at every gulp.



Section of Cofferdam.

Experience with Concrete in Fortifications.

For a good many years, a very large amount of concrete has been used annually on fortification works under the direction of the Corps of Engineers, U. S. A., the requirements for some of this work being rather unusual on account of the special conditions of its use. Natural cement concrete was first employed, and while it was practicable to obtain mass and strength, the workmanship was so poor that some of the old emplacements leak like sieves. According to an important paper on the subject by Major E. E. Winslow, Corps of Engineers, recently published in the "Journal of the U. S. Artillery," it seems to have been thought in the early days that well mixed concrete was practically water-proof, at least when the top surface was smooth and had a slight slope for drainage. This is probably true, or at least nearly true, in the best quality of concrete, when it is comparatively fresh, but, he states, the irregular contraction and expansion due to temperature changes, and the fact that perfect ramming is never possible, are certain to cause minute cracks in the concrete mass. Water is drawn into these cracks by capillary action and finally finds its way below, so that no construction of concrete can be considered absolutely water-proof. It is highly important, however, that the surfaces of the loading platforms, and especially the practically flat surfaces over the magazines and galleries should be finished with a granolithic surface of the utmost smoothness possible, so that all the water will tend to run from it and not seep into it. But in spite of everything that can be done, concrete will permit the water to percolate through it.

As an aid to getting rid of this seep water, there is one expedient which was introduced by Mr. James Ware, the assistant in immediate charge of the fortifications of the Fort Monroe District, which appears to be of considerable value, and should be always followed, Major Winslow believes. He describes it as follows:

Good concrete is placed in layers of from 6 to 8 in. in thickness, and then thoroughly rammed. These layers follow each other at short intervals, but the ramming of one layer brings water to its surface and more or less dust will accumulate upon it before the next layer is put upon it, so that, in spite of everything that can be done, two successive layers never bond together as well as the concrete in a layer is bonded in itself, and there is always left, between two successive layers of concrete, a surface where the bonding is comparatively slight. Now water, percolating through one layer and reaching the surface between it and the next layer, will spread over this surface until it finds its way still further down, and if these surfaces are made perfectly horizontal, the spreading may be in any direction; if, however, these separate layers of concrete, instead of being made horizontal, are given a slight slope, water reaching a surface of separation will have a tendency in spreading to spread down hill before it seeps into the next lower layer; in this way seep water is, while seeping through the mass of concrete, gradually shed off in one direction. For the above reasons, Mr. Ware begins all the concrete work of his parapets, and especially over his magazines, not in horizontal layers but in sloping layers, and builds them up in this way. By making these separate layers slope in such a direction as to turn the water off to a side where it will do little or no harm, a considerable improvement is effected.

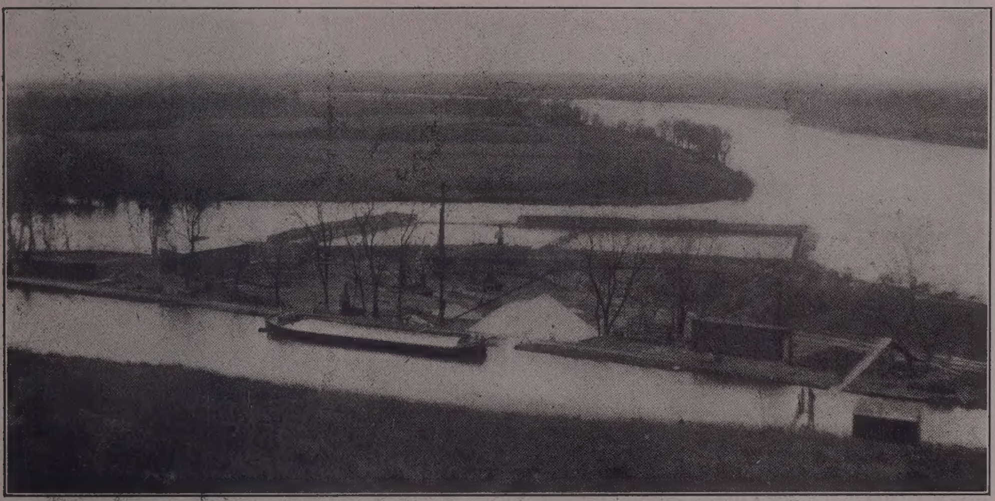
In this connection it should be noted that it seems to be the general consensus of opinion that the impermeability of concrete is increased by mixing and placing it very wet. Some officers advocate mixing it so very wet that it is literally poured into the framing. Such concrete is far too wet to ram and only a little puddling and poking is attempted.

It is usual to build the granolithic surface in blocks, so that even if the work be begun immediately after the completion of the mass below it, the last blocks will not be placed until the concrete below has thoroughly set, and the bond will be very poor. Usually this will give no trouble, but if it be done immediately in front of the gun, the blast effect is apt to loosen this thin concrete layer and tear it away, and for this reason the part of the parapet subject to blast effect must have the upper 3 or 4 ft. finished as a single mass as rapidly as possible, and without delays of any kind, the top surface being smoothed off with a trowel or float.

In the older Rosendale parapets great difficulty was found in getting concrete that would stand the blast at all. In fact, Rosendale concrete had not the requisite strength, and where very heavy guns are mounted so as to fire over Rosendale parapets it has usually been found necessary to tear away 5 or 6 ft. of the mass and replace it with Portland cement. Metal blast plates were tried and were found to be unsatisfactory.

Concrete when hard and dry is nearly white, and the glare from such a surface, exposed as it usually is to the sunlight, is very great and disagreeable, and it was not long before the artillerymen began to complain and request that the surfaces might be darkened. Darkening of the concrete surface has been attempted in several ways. One method is to mix lampblack in the concrete that is to be near the surface, in the same manner as is done in laying granolithic walks. In vertical walls, such a use of lampblack was practicable only where a plaster coating was used. It has been found, however, that the darkening of the surfaces made by lampblack in this way lasts only a comparatively short time, in fact it may be noticed that granolithic pavements which are quite dark when first laid rapidly wear lighter.

Another method of darkening the surface was to use lampblack in the form of a cement wash to be applied to the surface of the concrete. Lampblack is not soluble in water and it is necessary, therefore, to reduce it to the form of a solution by using wood alcohol or other cheap solvent. An ordinary cement wash of cement, water, and sometimes a little lime, would then be mixed up and the dissolved black would be added in the proper proportion. Such a wash would be applied with a brush in the same manner as white wash. This custom was in vogue for some time at Fort Monroe. When fresh, walls prepared in this way would be fairly nice looking, but in course of time the lampblack would be washed away by rain, and generally irregularly so that after a few months the walls would be rather ugly to look at. Furthermore, for some time after it was applied the black would rub off on clothes rubbing against the walls.



View of Site of Power House of The Economy Light & Power Co.

Another method of darkening the walls, that has been extensively used, has been by the application of boiled linseed oil applied in thin coats quite frequently until the wall had absorbed sufficient oil to give it a proper hue. Sometimes a little pigment would be mixed up with this oil. This coating was also supposed to make the walls to some extent waterproof. The attempt has also been made to prevent water from seeping into comparatively flat surfaces by applying this oil. Although the coating is fairly efficient as a waterproofing when first applied, new applications have to be made quite frequently to be effective. Furthermore, as far as horizontal surfaces are concerned it must be noticed that after several applications of this oil coating the surface will be a little too slippery to walk on easily.

It is needless to say, of course, that besides the dark coats mentioned above, there have been a number of attempts to apply different kinds of paint to concrete surfaces, both paints mixed with oil and paints mixed with water. A number of applications of patented and specially prepared coatings have also been used. Thus Battery Parrot, the newest battery at Fort Monroe, was painted some years ago with "concrete-waltum." This was supposed to render it waterproof. From reports received after this had been applied for a year, it is understood to be quite efficient. It is, however, quite expensive.

In connection with the subject of painting concrete, there is one important point to be noted, and that is the effect of the oils upon cement. Oil applied to concrete, at first, seems to have no effect upon it, but experiments have been made with briquettes composed even of neat cement and having a tensile strength of from 800 to 1,000 pounds per square inch. These have been painted when several months old with coatings of different kinds of oil. For a considerable time nothing would be noted, but eventually there would develop a sort of crumbling, and Major Winslow has seen briquettes that have been reduced absolutely to a state of powder due to the slow action of an oil upon them. Furthermore, it does not seem to have been yet definitely determined to what this effect of the oil is due, as it seems to occur sometimes with all kinds of oil, whether vegetable, animal, or mineral, while at other times the effect will not be noticed at all.

Owing to the effect of this oil, considerable care has to be taken in painting concrete surfaces. It was first found that, where the paint was upon a plaster coat, the application of the paint seemed to have a tendency to accelerate the peeling off of the plaster coat, the oil working its way through the plaster to the surface between the plaster and the concrete, and gradually weakening the already weak bond between the two substances. Furthermore, as stated above, this action is frequently very slow, so that care has to be taken not to jump at conclusions too rapidly, as to the efficiency of any particular kind of paint for concrete surfaces.

THE SAND-LIME BRICK INDUSTRY is increasing in this country according to the United States Geological Survey, whose reports show that the total value of the sand-lime brick produced in 1906 was $1,170,005, an increase of 20 per cent. over the value in 1905. Almost 90 per cent. of the product is marketed as common brick, a result that could hardly have been foreseen when the brick was first introduced into this country. The total number of plants has increased from 16 in 1903 to 57 in 1904, to 84 in 1905, and to 87 in 1906, and bricks of this character are now made in nearly every State in the Union. New York is the largest producer, the value of the product in 1906 amounting to $191,000; and Michigan, with a product valued at $174,921, is a close second. California, Florida, Indiana, New Jersey and Pennsylvania each produced in 1906 sand-lime bricks to a total value of more than $50,000.

The Predetermination of Train Resistance.

The latest paper on the subject of train-resistance formulas was read by Mr. C. A. Carus-Wilson before the Institution of Civil Engineers, who first reviewed those aspects of journal-friction, rolling-friction, track-resistance, flange-ac-train-resistance. The conclusion reached is that tion and air-resistance which are elements of the component parts of train-resistance may be divided into three groups distinguished by their relation to the speed. The resistances in Group 1 are independent of the speed, and include journal-friction, rolling-friction, and track-resistance. Group 2 includes the resistance caused by flange-action, which varies as the first power of the speed. Group 3 includes all forms of air-resistance, which vary as the square of the speed. The resistance-equation is thus shown to be of the form $R = A + Bv + Cv^2$.

For the purpose of determining the constants the author selects the tests made by Mr. Barbier on the Northern Railway of France, as being the most complete and reliable of which full records have been kept. These tests were made on four-wheel and bogie coaches, and a comparison of the results obtained in the two cases, as represented by curves, furnishes a means of arriving at the constants in the resistance-equation. These constants depend upon the type of rolling stock under test, and formulas are deduced by which the constants for any given type of rolling stock may be obtained.

The resistance-formulas are applied in the paper to a number of different cases in order to ascertain how far they afford a correct predetermination of the resistance of trains made up of rolling stock entirely different from that tested on the Northern Ry. of France. For this purpose a number of the most reliable tests available are selected, the resistance is computed by the aid of the formulas, and the resistance-curve is then obtained and compared with the results of each test. The tests considered are the following:

(1) Tests of bogie-coaches on the Lancashire & Yorkshire Ry.—These coaches differ materially from those tested by Mr. Barbier. The curve obtained by the application of the formulas show a close agreement with the test results, the mean difference at eight selected speeds from 10 to 80 miles per hour being 3 per cent.

(2) Tests of four-wheel goods-wagons on the London & North-Western Ry.—Here the calculated resistance is 5 per cent. below that obtained by test.

(3) Tests on eight-wheel bogie goods-wagons on the New York, Ontario & Western Ry.—The calculated value is 8½ per cent. less than the observed value.

(4) Tests of eight-wheel electric motor-coaches made by the St. Louis Electric Railway Test Commission.—The resistance obtained from the formulas shows a close agreement with that obtained in the test.

(5) Tests of twelve-wheel high-speed bogie-coaches at Zossen.—The calculated resistance differs from the test value by a constant amount of 100 lb. being a difference of 7½ per cent. at 60 miles per hour.

The following practical topics are discussed in the light of the conclusions reached:

(1) Journal-friction in its relation to train-resistance and its possible reduction by roller bearings.—The real value of roller-bearings in railway traction is stated to lie in the reduction of running-resistance and consequent saving of energy, and not in the reduction of starting-effort. The results of tests with roller-bearings on the Eastern Bengal State Ry. show the saving actually obtained was 1 per cent. greater than that calculated by the use of the resistance-formulas.

(2) The influence of the track on the resistance of bogie-coaches.—The resistance of a coach is stated to depend largely upon the wheel-base of the truck, and the relation of the weight of the bogie-trucks to that of the whole coach.

(3) The effect of electrical driving on the resistance of bogie-coaches.—The weight of the motors and the extra weight of the motor-trucks in electrically-driven coaches increases the flange action and the total resistance of such coaches. The resistance of electrical motor-coaches is in some cases as much as 54 per cent. greater than that of trailing coaches running at the same speed under similar conditions.

(4) The reduction of the resistance of goods-wagons by the use of bogies.—The influence of the bogie on train-resistance is shown to be greatest in the case of goods-wagons.

(5) The relation between the tractive efforts required to haul loaded and empty bogie goods-wagons.—Since flange-action depends upon the ratio of the weight of the bogie to that of the whole wagon, it follows that the resistance per ton of a loaded bogie-wagon must be less than that of the same wagon empty. This is a matter of general experience, and can only be explained on the above hypothesis. The results of tests are given in which a train of bogie-wagons was hauled over a considerable distance backwards and forwards, first loaded and then empty. The ratio of the mean drawbar-pull in the two cases was 0.56. When the resistances are calculated by the formulas, the ratio is found to be 0.62.

(6) The incidence of train-resistance on flange and rail-wear.—The energy expended in overcoming flange-resistance is represented by the wear of tires and rails. Tables are given to show how much greater this wearing action is in some cases than in others.

(7) The reduction of flange-action by mechanical contrivance.—It is shown that by giving the bogie a lead, as is done in Timmis's bogie-lead, the flange-action of the bogie can be reduced, and that the saving depends upon the ratio of the bogie wheel-base to the distance between the bogie centres, and also upon the ratio of the bogie weight to the total weight.

(8) The effect of side play on train-resistance, and its possible limitation.—The amount of play between the flanges and the rail is an important factor in train-resistance. The want of uniformity in current railway practice in this matter is illustrated by a table giving the amount of side play adopted on thirteen different railways in Great Britain, in the United States, and on the Continent. The increased resistance and wear occasioned by large flange-play suggests the importance of a reduction of the play to a standard ⅜ in. as on the London & South-Western and other railways.

(9) The relative importance of air-resistance.—The resistance of the air with a train of bogie-coaches, running at 60 miles per hour, amounts to about one-half of the total tractive effort required to haul the train. The experiments conducted by the St. Louis Elecric Railway Test Commission show that a large reduction can be made in the front and rear air-resistance by shaping the ends, and that by this means a saving can be effected of 10 per cent. of the total tractive effort with a long passenger-train, and 30 per cent. with a single coach.

A DIAGONAL-PIT ENGINE-HOUSE of rectangular form is under construction at the new steel plant of the U. S. Steel Corporation at Gary, Ind., which will be used for 35 switch engines instead of the usual "roundhouse" form of shelter. The pit tracks accommodate two locomotives each and connect outside the building to a ladder track, thus eliminating turntable or transfer table.

A Reinforced Concrete Observation Tower.

An ornamental observation tower has recently been erected on a commanding elevation in the Vicksburg National Military Park at Vicksburg, Miss. The Park Commission called for competitive plans for this structure, inviting designs contemplating the use of either structural steel or reinforced concrete. The plans that were accepted were prepared by Mr. Art. J. Dyer, Mem. Am. Soc. C. E., and called for a reinforced concrete tower consisting essentially of five circular platform landings, the lowest one a little above ground level and the others of successively decreasing diameter, supported on columns as shown in an accompanying illustration, the topmost landing being covered with a roof surmounted by a flag staff.

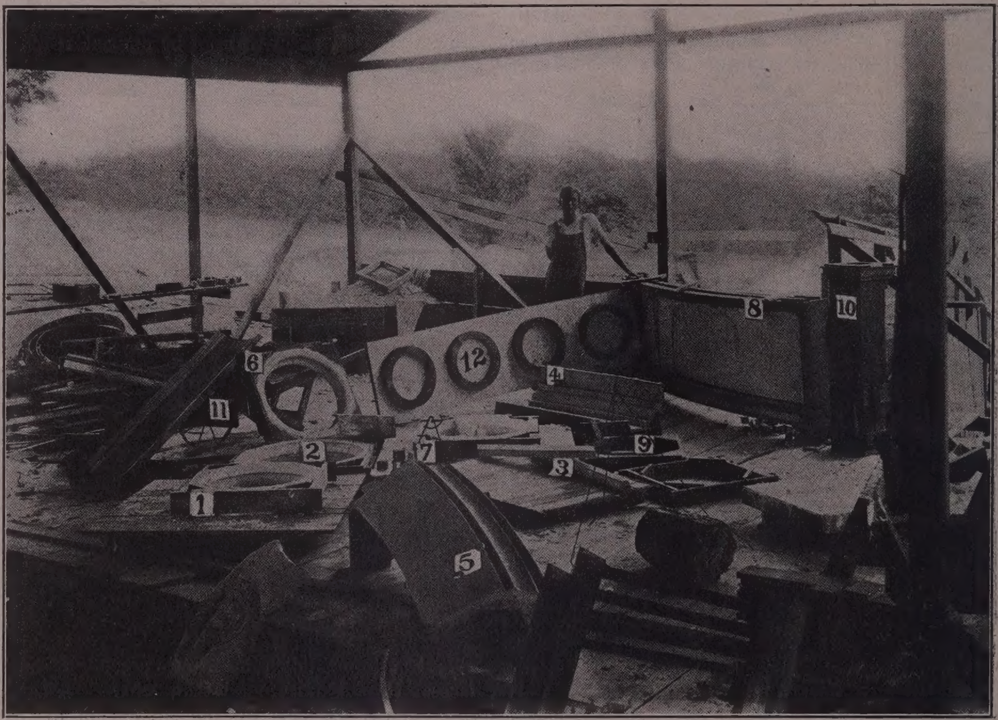
The top landing is 82 ft. above the ground and the height of the tower, from the ground to the base of the 20-ft. flag pole, is 97 ft. The five landings, counting from the top to the bottom, are 17 ft. 6 in., 23 ft., 29 ft. 10 in., 37 ft. 8 in., and 46 ft. in diameter, respectively. The columns in the several stories are 12, 16, 20, 24 and 28 in. in diameter, respectively. The entire tower, including the stairs, hand rail, wall and even the movable ring supporting the halyard plate was constructed of reinforced concrete, the only metal exposed being the bronze halyard pulley.

Plain round bars were used for reinforcement in all columns, girders and floors. As additional reinforcement in the columns, the vertical rods are wound spirally in both directions with No. 11 steel wire.

The stairs are spiraled around a 14-in. cylindrical column which receives lateral support at each landing by attachments to the landing floors. Each riser in the stairs is a 2 x 9-in. cantilever beam projecting from the columns and reinforced with one ½-in., and two ⅜-in. rods. Each tread is a 2-in. slab connecting two risers and tied to them by twelve No. 11 wires, each of which extends through three risers and two treads. The treads are 15 in. wide at the outer end and 4 ft. long. The balustrade consists of a 3 x 5-in. hand rail reinforced with two ⅜-in. rods, and a series of 2 x 2-in. balusters, each of which is reinforced with four No. 11 wires. The balcony railings are 2 in. thick and are reinforced with ⅜-in. rods and steel wire. The flag pole is 4 in. and 7 in. in diameter at the top and bottom, respectively.

A large number of special moulds were required to form the various parts of the tower. Some of these are shown in an accompanying illustration in which the significance of the numerals is as follows 1, 2, 6, 7 and 9, column mouldings; 3, multiple form for balusters with 12 balusters in place; 4 and 5, forms for cornice blocks and finished blocks, respectively; 10, form for stair post; 11, part of column moulds; 12, mould for balcony railing.

The columns all taper from the middle to the top, the curve of the taper being parabolic and this necessitated great care in preparing the moulds. These were made of cypress strips arranged somewhat like staves in stave-pipe. Solid concrete columns were not required in the two lowest stories, and these columns were accordingly built around cinder cores. The cornices on the second and third landings were cast on the ground in blocks 4 or 5 ft. long and about 2½ in. thick. The reinforcing wires in these blocks projected through their upper surfaces at a number of points so that when the blocks were held in position on scaffolding and the floor laid over them the projecting wires were imbedded on the floor concrete, securely tying the blocks to it. The other cornices were cast in place in plaster of paris moulds with their respective floors.



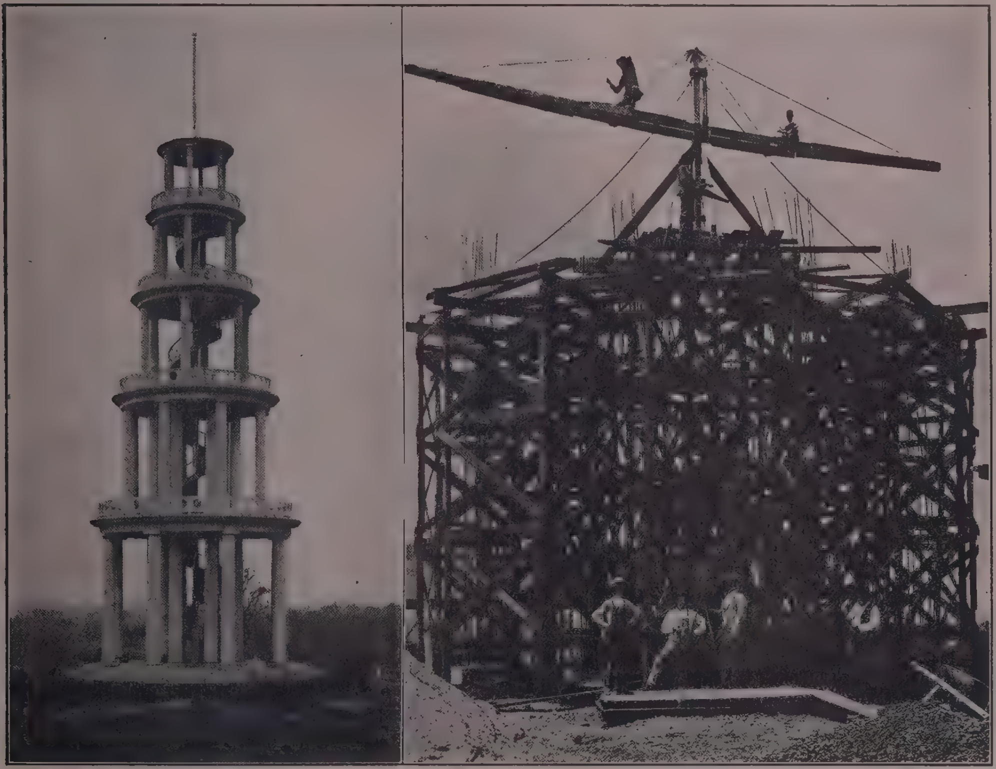
Moulds Used for Concrete Observation Tower at Vicksburg, Miss.

A large amount of intricate scaffolding was required to support the column and floor forms and carry the weight of a balanced-beam derrick of the form shown in an accompanying illustration, with which the forms and all the materials were handled. The method of procedure was about as follows: Scaffolding was first erected on the pedestal for the first-story columns and the second floor; the derrick was mounted on top and the first story was completed, including the stairs with the balustrade up to the level of the top of the second floor; the scaffolding was then taken down and re-erected on the second landing with the derrick mounted on it and the second story was erected. In a similar manner the successive stories were built to the top of the tower.

The concrete used was a 1:2:4 mixture of Portland cement, granite sand from Georgia and crushed limestone from Nashville, Tenn. All the finished surfaces were obtained with the forms or by floating where necessary, no plastering being done. The structure was completed in Nov., 1907, and although so far South, several sections of the balustrade hand rail had to be replaced on account of freezing. The work required in all about 123 working days. The tower was built under the direction of the Vicksburg National Military Park Commission, Mr. Wm. T. Rigby, chairman. The W. T. Young Bridge Co., Nashville, Tenn., was the contractor; Mr. Art. J. Dyer, chief engineer, being in personal charge of the work.

The Width of Roadways.

The width of roadways was discussed recently in a paper read before the League of Iowa Municipalities by Mr. Andrew Rosewater, city engineer of Omaha, who believes that a great waste of money is caused in many cities by unnecessary width of paving. On the average, cities have about 20 miles of streets per square mile of area, which, if 30 ft. wide, would mean over 350,000 sq. yd. of pavement. At $2 per square yard this means an expenditure of $700,000. Traffic on residence streets is much less than is generally supposed, the heaviest in Omaha probably not exceeding 5 to 10 teams per hour traversing a given block.



Concrete Observation Tower and Falsework for Its Erection.

Many residence streets which several years ago were made 40 ft. between curbs have later been reduced to 30 and even 20 ft. without any objectionable results, but with a very large saving in cost for paving. One of the chief objections raised against the 20-ft. roadways was that teams could not turn round in them, and that nothing less than 30 ft. would permit of the turning around of a fire engine, but in reply Mr. Rosewater stated that for such traffic as used residence streets it would be no great hardship to travel half a block to the nearest intersecting street. He did not advocate decreasing the total width of residence streets, but would assign 50 ft. as a minimum width and would prefer a width nearer 100 ft.; the space not occupied by either street or sidewalk paving to be sodded, planted to trees and treated as parkways.

Burning Illinois Coal without Smoke.

Some months ago there appeared in many newspapers a report that Prof. L. P. Breckenridge had invented a new and greatly improved method of burning soft coal, an assertion that brought him so many inquiries that he had a mimeographed letter prepared to take care of this part of his correspondence. In Bulletin 15 of the University of Illinois Engineering Experiment Station, of which he is director, a complete statement is made by him of the nature and extent of his work, which he frankly states does not add anything but the results of careful tests and observations of boiler furnaces under operating conditions to the information in the paper by Mr. A. Bement on the "Suppression of Industrial Smoke," read before the Western Society of Engineers in 1906.

Prof. Breckenridge states the basic principle of smoke prevention as follows: "Any fuel may be burned economically and without smoke if it is mixed with the proper amount of air at a proper temperature." During the last two years the 2,000-h.-p. boiler plant of the University of Illinois, consisting of nine units, has been operated practically without objectionable smoke for nine-tenths of the time. Over two hundred separate boiler tests have been made in this plant to determine the economy of operation and for a study of furnace conditions. Many changes have been made in details of the furnaces and the baffles of the boilers in order to determine their effect on smoke production. The boiler units were as follows:

Boilers 1 and 2.—Babcock & Wilcox, 275 lb. steam pressure in one case and 150 lb. in the other, 150 h.-p. rating, standard vertical baffles, Babcock & Wilcox chain grate stoker, draft 0.75 in. These units can be run without smoke at 50 to 120 per cent. of their rating.

Boiler 3.—Stirling, 150 lb. steam pressure, 260 h.-p. rating, Green chain grate stoker, standard baffles and combustion arches, 0.75-in. draft. This unit can be run without smoke at 50 to 140 per cent. of its rating.

Boiler 4.—National water-tube, 150 lb. steam pressure, 250 h.-p. rating, 0.75-in. draft. It was formerly equipped with a Murphy furnace and ran without smoke except while the fires were being cleaned. It now has a Green chain grate stoker and is run without smoke at 50 to 120 per cent. of its rating.

Boiler 5.—Babcock & Wilcox, 150 lb. steam pressure, 220 h.-p. rating, Roney stokers, standard vertical baffles, 0.75-in. draft. When handled carefully and not pushed beyond its rating, this furnace did not give off smoke denser than a light gray corresponding to shade 2 of the Ringelmann scale.

Boiler 6.—Babcock & Wilcox, 150 lb. steam pressure, 220-h.-p. rating, Roney stokers, and 0.75-in. draft, duplicating No. 5 in all respects except the baffling, which consisted of special fire-clay tile laid on the water tubes so as to make the gases pass over the bridgewall and under a tile arch nearly to the rear header, then forward along the lower half of the bank of tubes nearly to the front header, and then back along the upper half of the bank of tubes to the outlet. This course is at right angles to the one taken when the standard vertical baffles are used. This unit can be run without smoke at one-half to full rating. Experience indicates that this use of baffles parallel to the tubes instead of perpendicular to them requires a somewhat higher draft or more tubes in the vertical rows.

Boilers 7 and 8.—Stirling, duplicates of No. 3 except they have Stirling bar grate stokers. Can be run without smoke at 50 to 140 per cent. of the rating.

Boiler 9.—Heine, 150 lb. steam pressure, Green chain grate, usual combustion arch, tile roof furnace of type originated in 1901 by Mr. W. L. Abbott, of Chicago, adjustable water back at bridgewall, 210 h.-p. rating, induced draft. This unit can be run without smoke at 50 to 140 per cent. of its rating. This boiler is a duplicate of that used in the government fuel tests at St. Louis except that it has a stoker instead of depending on hand-firing. Over a hundred 10-hour tests with various kinds of Illinois coal have been made with this setting, and in every trial the record has been "No smoke all day." This is the setting to which Prof. Breckenridge has referred in recent addresses as one impossible to make smoke.

The fresh coal, fairly uniform in size, advances slowly from the hopper along on the grate toward the furnace where the temperature is very high. The combustible volatile matter is continually being distilled from the coal, more and more rapidly, but with much uniformity, while it is passing under the combustion arch. Some of the necessary air flows in through the coal in the hopper, more through the grate under the arch, but by far the most flows through the redhot coals on that part of the grate beyond the arch. This air is thus heated and made ready for combining with the volatile products flowing from beneath the arch, and all together mix and roll along on the bottom of the tiles forming the roof of the furnace. The bottom row of boiler tubes is covered with suitably formed tiles, which prevent the still actively mingling gases from being cooled by coming in contact with the tubes, and so the combustion processes go on until completed before reaching the place where the gases pass in among the cooling tubes. The tiles in the adjoining rows touch each other so that no gases pass between them.

There is a rate of driving a boiler furnace which, if exceeded, will result in producing smoke. This rate varies for different types of furnaces and for the various methods of baffling or kinds of mixing piers used. It also varies for different kinds of coals. A strong draft will make a large air supply possible, and allow thicker fires or finer coal to be used. The possibility of sufficient air makes a furnace smokeless when an insufficient supply caused by a weak draft might cause the production of smoke. There is an always increasing tendency to drive boilers and furnaces a little harder. Boilers that were purchased for 1,000 h.-p. a few years ago are now being forced to 1,400 and 1,600 h.-p. This means of course larger grate areas and a much higher rate of combustion per unit of grate area. As far as the boilers are concerned, they seem to be ready and willing to transmit about the same proportion of the heat available to the boiler as ever.

It is doubtful, Prof. Breckenridge says, if constructive furnace details have kept pace with the demands for the higher rates of combustion and at the same time have provided efficient smoke preventing plans. In other words, when boilers are forced much over 30 per cent. of their rated capacity the probability of smoke from their furnaces rapidly increases. Nothing inherent in the boiler itself is at all responsible for smoking furnaces, for it is the total amount of volatile combustible evolved in the furnace per unit of time that imposes duties upon those constructive features of the furnace and combustion chamber which are designed to furnish the proper amount of suitably warmed air to the furnace and to provide for its effective mingling before the products of combustion reach the cooling surfaces of the boiler. It would seem necessary, therefore, that until further advances are made in furnace design and methods of operation, when a plant has reached the point of perhaps 140 per cent. of its rated capacity, additional boilers ought to be added if only in the interest of a less amount of smoke.

The horizontal fire tube boiler is still much in use in the smaller units of from 50 to 150 h.-p. It was brought into prominence in the early days of American steam boiler practice as the natural successor of the plain cylinder and flue boilers, all of which were externally fired. It soon became the standard type of boiler throughout manufacturing New England, where in many places it still retains its position on account of its cheapness and its economical operation with all grades of anthracite and many grades of bituminous coals, especially those containing a high fixed carbon content.

With the coals just mentioned the combustion takes place mostly on the grate or at a short distance above it. Many plants have been installed with this type of boiler, in which the grate has been placed not more than 14 to 16 in. beneath the boiler. These plants have burned anthracite coal successfully. With the introduction of the West Virginia bituminous coals containing small amounts of volatile combustible matter the grates were lowered under this type of boiler to 24 and 30 in. with good effect. Still, with either coal, much the greater part of the heat was generated on or near the grate and the heat made available for transmission was largely radiant heat. The plates directly over the fire itself transmitted a correspondingly large part of the heat of the coal to the water in the boiler. The satisfactory performance of the fire tube boiler with eastern coals together with its availability made it naturally the boiler to be adopted by manufacturers moving westward with the center of population.

It is easily seen, however, that with Illinois coals carrying 30 to 40 per cent. of volatile combustible matter and burned at rates which produce flame lengths of from 5 to 20 ft., this type of boiler as usually set is by no means adapted for the smokeless consumption of this kind of fuel. There is, in fact, no better method of producing dense black smoke with Illinois coal than to install a horizontal fire-tube boiler with the usual furnace, and hand fire such a plant with run-of-mine coal. The method of introducing the coal directly into the hot furnace, in fine dust and large lumps, prevents slow or uniform distillation of the gases; the air supply through open doors, through holes in the fire, or through a fuel bed of varying thickness is neither correct in quantity nor is much of it properly heated; the mingling products of combustion come in contact with the cool surface of the plates of the boiler, reducing the temperature of the gases below the ignition temperature before combustion is completed.

Having in view these defects of the usual plan of operating the fire-tube boiler with Illinois coal, many ways suggest themselves by which these faults may be corrected. It is possible to burn Illinois coal without smoke with fire tube boilers, but the furnace requires special treatment and such settings are not common. The plans usually proposed are either low-set stokers or extended Dutch oven furnaces. When hand-firing is adopted the wing wall furnace or other form of mixing baffles or piers is of great assistance. With any of these devices careful firing is very necessary for satisfactory results. The twin brick arch furnace which keeps the gases away from the boiler plates altogether is an effective smoke preventive. Careful firing with low rates of combustion (12 to 16 lb.) per square foot of grate, assisted by automatically controlled air supply, will often enable these settings to be run so as to escape the fines of city smoke inspectors. Horizontal tubular boilers are often adopted on account of their cheapness, and when such is the case the addition of any special furnace constructions or any special devices to aid in smoke prevention, is seldom given any consideration. From what has been said it is doubtless evident why this type of boiler is so frequently found to be one of our worst smoke offenders.

There are many small power plant units that are hand-fired which smoke badly. The best method of hand-firing for smokelessness is also the best method for attaining economy. There are three generally recognized methods of hand-firing: (a) The spreading, (b) the coking and (c) the alternate. The first is satisfactory and generally used for anthracite; the second for coking coals and the last for non-coking coals. It is the alternate method that is best suited to Illinois coals. This method is described as follows: The fuel bed area is divided into equal parts two, four, or six, depending on the size of the entire surface. The fresh coal is fired alternately on one-half of these areas at a time at such intervals as may be necessary to hold the steam pressure. Depending on the rate of driving, these intervals will vary from one to five minutes. For small areas first one-half the surface of the fuel bed is covered and then perhaps three minutes later the other half. This method allows much of the air supply to come through the bright fuel bed and thus become heated and suitable for mixing with the highly volatile content which is being rapidly driven from the freshly fired coal on the other side. Just because fresh fuel has been spread over one part of the fuel bed, the air most needed at that moment cannot as easily flow through it, and another part of the fuel bed should be left free for its passage at that time.

When the fuel bed area is very large, some checker board system of firing may be adopted which, when alternately fired and left free for air passage, will result in a large reduction in the amount of smoke produced by the too common method of spreading the coal over the entire surface at each firing. It must not be forgotten that a large supply of warm air is needed immediately after fresh fuel is spread over a part or all of the fuel bed; this is best supplied as just explained, but it may be advantageous to provide for still more air by leaving the fire doors open slightly just after each firing. There are several devices on the market which provide for an air supply over the fire, which are turned on with the opening or closing of the fire door and which can be arranged to close at the end of any desired time depending upon the rate of driving and frequency of firing found desirable. The firing of small amounts of coal at frequent intervals produces less smoke than firing large amounts at longer intervals. The latter method, however, usually proves less tiresome to the fireman and is for that reason more frequently adopted.

Having in mind the horizontal fire tube boiler, the distance from the bottom of the boiler to the grates should be from 30 to 34 in. At this distance the flame from Illinois coals will sweep along the bottom of the boiler and much smoke will result. Still it must be borne in mind that a large part of the heat to be obtained from the burning of the fixed carbon part of these coals is transferred to the shell in the form of radiant heat and for this purpose the grate should be near the boiler. While it is necessary in preventing smoke, that the flames be kept from the cooling surfaces of boilers, this cannot be accomplished by simply lowering the grates under a horizontal fire tube boiler. For boilers of this type some form of furnace extending partly or entirely in front of the boilers and either hand fired or fed by stokers of the Murphy type would undoubtedly furnish a satisfactory solution to the smoke problem.

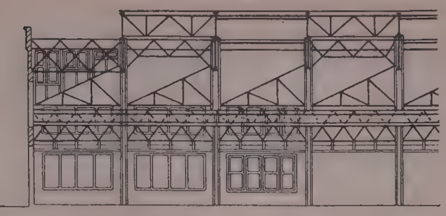
When the coal fed into a furnace is fairly uniform in size it is much easier to burn it without smoke than when it is of different sizes. The standard commercial sizes are all that are required, such as Nos. 1, 2, 3, 4, or 5. Take, for instance, the chain grate stoker; the very principle of its operation, complete consumption of the coal while it travels the length of the furnace, makes it very evident that if small pieces of coal are just consumed, the very large pieces will not be consumed. Just to what extent it will pay to size coal for regular use is not yet very clear, but experiments reported by Mr. W. L. Abbott in a paper before the Western Society of Engineers, makes it evident that the influence of variation in size of the fuel used is of much more importance than has heretofore been generally believed. In these tests the capacity as well as the efficiency of the plant tested increased rapidly with the size of the coal used between the average sizes of 0.12 and 0.30 in., after which both these factors dropped again.

The washing of coal, which removes a considerable part of the ash and sulphur, has proved very advantageous to many plants, especially where capacity has been an important consideration. The washing itself, however, does not make coal burn without smoke. The total volume of volatile combustible distilled per hour from each square foot of grate area must determine those furnace proportions necessary, with the various methods of coal supply to the furnace, which will with any kind of coal prevent smoke. Since Prof. Breckenridge began to use washed nut coal in his hot water residence heater and in his kitchen range, black smoke is seldom seen coming from his chimneys. Previous to the use of this coal the kitchen range pipe required cleaning at least once, sometimes twice each year. It is now three years since this pipe was cleaned. No soot now gathers on the underside of the stove lids as was formerly the case. A fire is easily maintained eight to twelve hours in the residence heater.

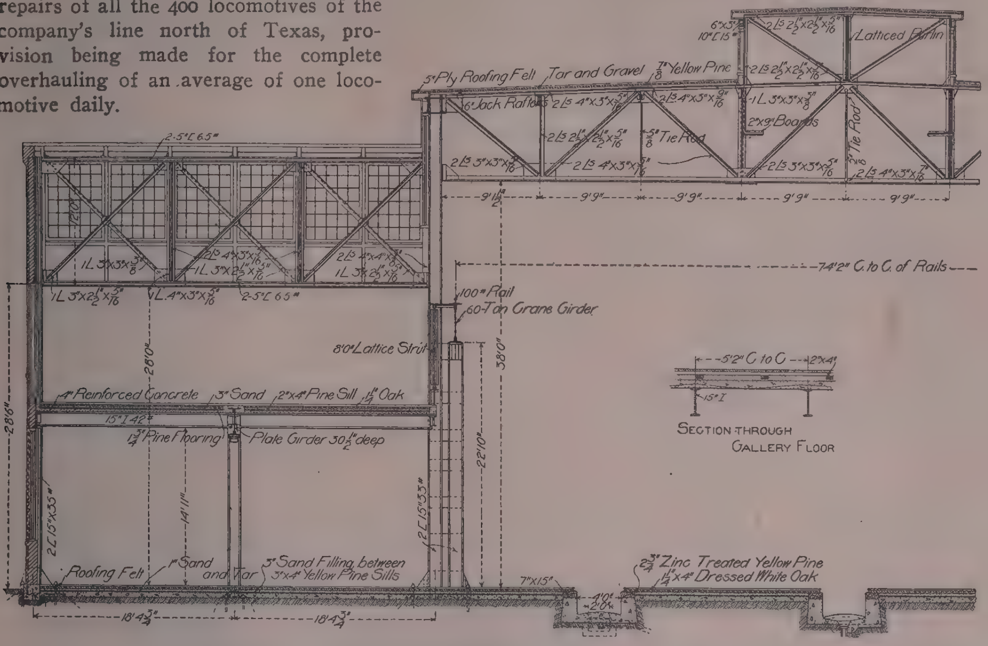
HUMP YARD SWITCHING has been inaugurated on the Great Central Ry. of England at its new terminal yard at Wath, where a heavy freight and coal traffic is handled. Special locomotives have been designed for pushing cars in trains weighing 1,200 tons up the back slope of the hump; they are fitted with three cylinders 120 deg. apart, in order to secure a more uniform tractive effort than is possible with the usual two-cylinder engine with cranks quartering.

Structural Features of the Railway Shops at Parsons, Kansas.

The new mechanical plant of the Missouri, Kansas & Texas Ry., at Parsons, Kan., has several large buildings, the most important of which is the 154x860-ft. locomotive shop. This is intended to provide for a considerable amount of new construction and for the maintenance and repairs of all the 400 locomotives of the company's line north of Texas, provision being made for the complete overhauling of an average of one locomotive daily.



Part Side Elevation, Locomotive Shop.



Section through Gallery Floor

Half Transverse Section of Locomotive Shop.

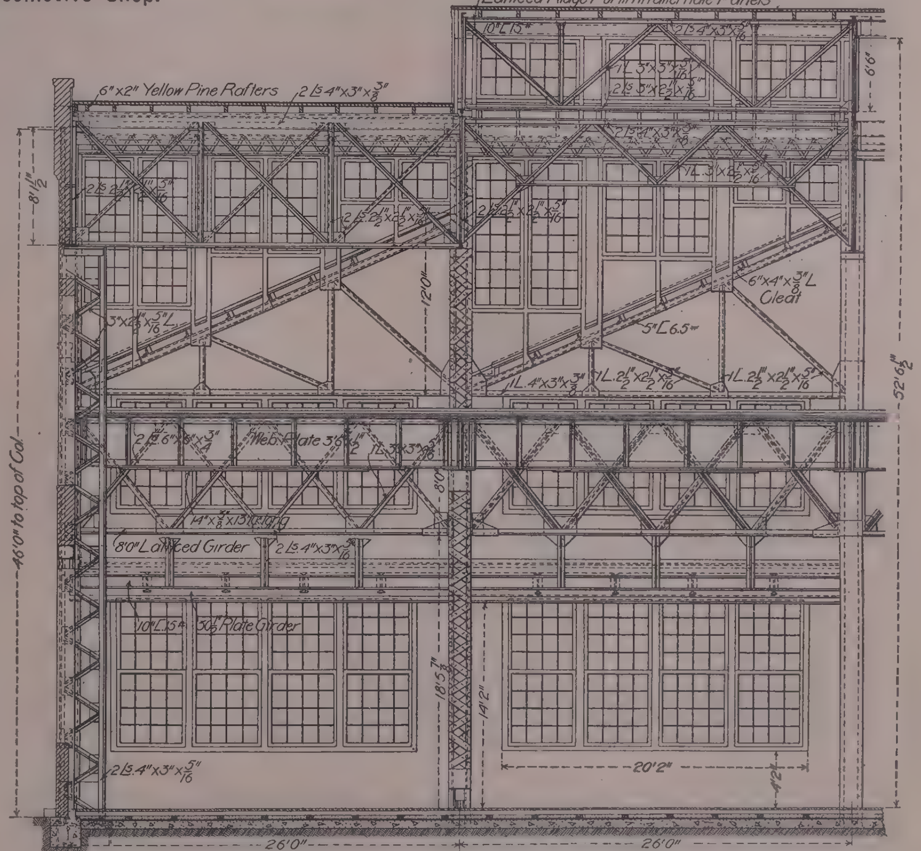
The locomotive shop has a 78-ft. center aisle 47½ ft. high to the main roof, and two 36 ft. 9½ in. side aisles, one and two stories high respectively. Two longitudinal tracks extend through the full length of the center aisle and a third one extends, most of the way, providing for the entrance and exits of locomotives and tenders, the latter being transferred by the overhead girder cranes to a set of short tracks at right angles to the longitudinal tracks.

The main aisle is commanded by two 60-ton girder cranes of 74 ft. 2 in. span with a clearance of 27 ft. above the floor. The one-story side aisle is commanded by two 10-ton girder cranes with a span of 33½ ft., and a vertical clearance of 16 ft., and on the opposite side, a 25-ton crane covers the area beyond the mezzanine floor. These cranes were made by Alfred Box & Co., of Philadelphia.

The walls are of brick with large window areas and the flat roof is of boards with tar and gravel covering supported by a steel framework with four main longitudinal rows of columns spaced 39 ft. and 75 ft. 9½ in. from the axis of the building. There is also, on the center line of the two-story aisle a longitudinal row of one-story columns supporting the second floor. The building is divided by 34 transverse bents into thirty-three 26-ft. panels which are structurally duplicates except for the riveting tower in one panel and for the four fan house extensions beyond the outer walls of the side aisles in the eighth panel from each end. The center aisle columns are higher than the wall columns, thus providing for clere-story windows above the side aisle roof. There is also a monitor 6½ ft. high and 19½ ft. wide, with side windows, on the center line of the main roof which extends over thirty-one panels of the structure.

An interesting feature of the construction is the arrangement of the transverse saw-tooth roofs which secure abundance of light in the upper stories of the wide side aisles. These roofs instead of being made, as is frequently the case, with separate frames placed on the regular roof trusses and thus involving a considerable extra weight of auxiliary construction, are ingeniously made with a special arrangement of the regular trusses necessary to support the roof so that no additional steel work is involved.

All of the column foundations are carried down in the clay soil to a depth of 5 ft. in open pits where forms were constructed and filled with concrete in the lower portion of which were embedded sets of four horizontal rails serving as reaction beams, to which are anchored the pairs of 2-in. vertical column bolts 5½ ft. long with nuts on the lower end engaging horizontal 8-in. transverse channels across the lower flanges of the rails. The foundation piers for the mezzanine floor columns are of similar dimensions, and in them the reaction rails are omitted. The tops of all column piers are 12 in. below the finished floor level, and the columns are seated on them with a ¼-in. grout joint.



Longitudinal Section at End of Locomotive Shop at Parsons, Kansas.

The superstructure is proportioned for a snow load of 10 lb. per square foot and a wind pressure of 40 lb. per square foot of vertical projection. The second gallery floor is proportioned for a live load of 300 lb. per square foot, and unit tension stresses are allowed of 16,000 lb. for static load, 20,000 lb. for wind load and 12,000 lb. in the crane girders. Expansion is provided for due to an assumed maximum variation of 160 deg. temperature, and the details and workmanship are generally in accordance with the specifications of the American Bridge Co.

All columns are made with pairs of 15-in., 33-lb. channels with their webs transverse to the axis of the building. The main aisle columns are substantially double with one side carrying only the roof trusses and gallery floor, the other side is a practically independent member carrying only the crane girder runway, and is attached to the other and longer member only by transverse connection plates not capable of transmitting vertical loads and by the common base plate or shoe which distributes the load of both members over the foundation pier. The runway girders are seated on the tops of these columns, thereby insuring concentric stresses and avoiding any possibility of eccentric stresses for the longer part of the column. All of the transverse roof trusses have the ends of their top and bottom chords field-riveted to the faces of intermediate and wall columns through vertical connection angles on end gusset plates. The side aisle trusses are so deep that they practically serve as knee braces and give great transverse rigidity to the columns, thus eliminating the necessity for diagonal sway bracing.

The intermediate columns are connected by longitudinal lattice girders 8 ft. deep with their top flanges in the same horizontal plane as the top flanges of the crane runway girders, to which they are latticed horizontally. In one aisle these girders simply act as longitudinal struts, but in the other aisle they carry the second floor of the gallery which is suspended from them by vertical members at panel points of the lower chords. The upper ends of the wall columns are connected by light triangular longitudinal lattice girders 12 ft. deep, built partly into the solid brick work of the wall. Like the transverse trusses these girders are so deep that their connection to the columns made the latter very rigid and avoided the necessity of knee braces for longitudinal diagonal members in the panels between the columns.

The main span transverse roof trusses are 9½ ft. deep in the center and 8 ft. deep at the ends, thus allowing for the pitch of the flat roof. They are of light construction with most of the compression members made with pairs of angles riveted together back to back, the largest of them being only 4 x 3 x ⅜ in. The principal web members are zig-zag diagonals with stiff verticals at the bottom chord panel points and ⅝-in. vertical tie rods at the top chord panel points to support the long double panels of bottom chords. Each truss was shop riveted and shipped in three pieces which were field-riveted together in a horizontal plane at the surface of the ground before erection. The monitor frames were shop-riveted complete before shipment.

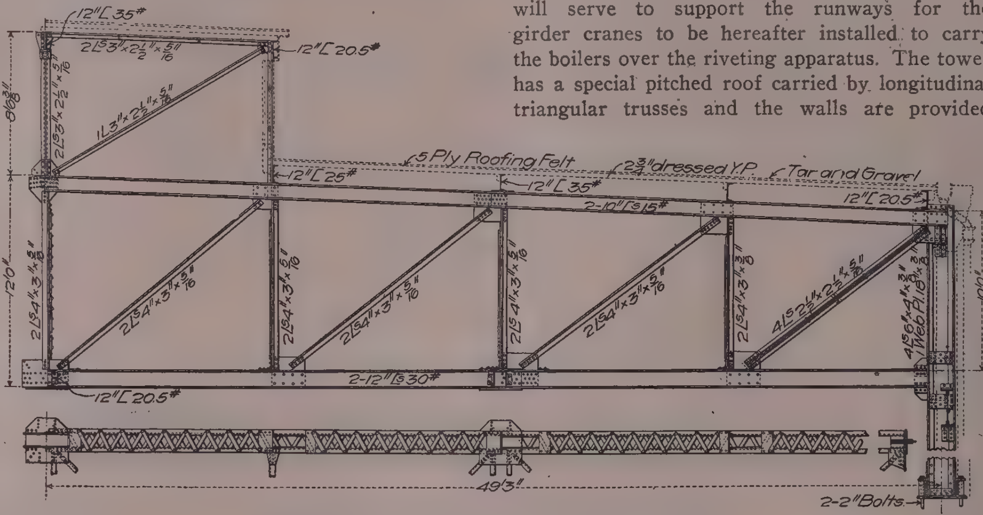
The main trusses carry six lines of 12-in. channel purlins, at each intermediate top chord panel points excepting the center ones. The special eave purlins have rectangular cross sections made with four angles latticed, and the ends are riveted across the inner and outer faces of the columns. The eaves purlins in the monitor are 10-in. channels, and the center purlin consists of a deep light lattice girder of the full depth of the monitor frame which serves as a longitudinal strut for the center of the span. Intermediate transverse wooden rafters are supported by the purlins and to them are nailed the ⅞-in. longitudinal tongue and groove roof boards.

The transverse roof trusses in each panel of the side aisle are connected at their four panel points by longitudinal triangular trusses with their bottom chords horizontal in the plane of the lower chords of the transverse trusses and with their top chords inclined to correspond with the slope of the saw-tooth roofs. These trusses are 12 ft. in maximum depth, and their members are made with single angles except the top chords which are 5-in. channels with webs in vertical planes. Transverse wooden purlins about 2½ ft. apart are bolted to angle clips on the top chords and support the ⅞-in. tongue and groove sheathing boards which are covered with tarred roofing felt on which are laid Ludowici tiles.

The vertical transverse planes at the deep ends of the saw-tooth trusses, that is the planes of the main transverse roof trusses, are closed between the top and bottom chords with fixed-sash windows about 7½ ft. deep reaching across the full width of the aisle. The spaces in the planes of the main columns between the eaves of the main roof and the rafters of the saw-tooth roofs have in each panel three windows of varying height with the triangular spaces below them closed by horizontal yellow pine sheathing covered on the outside with corrugated iron.

Almost the entire surface of the side walls of the monitor are filled with windows having sashes about 3½ ft. long and 4 ft. deep. These are arranged in pairs and are mounted on rollers to slide horizontally, and to be fixed in alternate panels. The sliding windows are operated simultaneously by means of 5/16-in. steel wire ropes. Access to the monitor windows is afforded by an 18-in. platform with longitudinal planks supported on the horizontal projections of pairs of angles riveted to the intermediate vertical posts of the main roof trusses, as shown in the general cross section. All windows are glazed with the best American double plate glass of a uniform size of 12 x 14 in.

In the end panels of the building resistance to wind pressure is afforded by special end wall columns with an I-shape cross section 3 ft. deep, which are made with pairs of flange angles latticed and virtually act as vertical lattice girders. The upper ends of these columns or girders are riveted to the lower flanges of longitudinal lattice girders 8 ft. 9 in. deep and one panel in length, which together with the lower longitudinal girders and the saw-tooth roof trusses brace the columns rigidly and substantially transform the end bents into a tower.



Half Span of Roof Truss of Smith Shop.

The longitudinal members of the building have fixed joints with the columns and transverse trusses except at every eleventh panel where they are provided with expansion joints and have their top and bottom flanges slide on horizontal seats to which they are connected by bolts through slotted holes.

The second floor of the gallery, which is proportioned for a live load of 300 lb. per square foot, is carried by transverse 15-in., 42-lb., I-beams spaced about 5 ft. apart. These beams are about 18½ ft. long and are made in two sets reaching from the side to the center of the gallery where they are supported on a line of 30-in. longitudinal plate girders carried by one-story columns at panel points. The outer ends of the I-beams are carried by a 30-in. plate girder built into the brickwork of the wall and the inner ends, adjacent to the center aisle, are carried by a 10-in., 15-lb. fascia channel to which they are web-connected and which is suspended from the longitudinal trusses as previously described.

The specifications for this floor provided that the top flanges of the 15-in. I-beams should first be covered with mounds of concrete 2 in. high, and that after the latter was partly set sheets of Clinton wire cloth should be stretched over it. This cloth is made with No. 6 wires 3 in. apart, and No. 10 wires 12 in. apart, and the fabric is laid in long lengths with the ends bent around the floor beams. Wire cloth is embedded in concrete slabs 1½ in. thick, well rammed and made 1:2:5 with Atlas Portland cement and screened steam cinders. The slabs are covered with a 1-in. layer of clean dry sand on which transverse 2x4-in. nailing strips are laid 3 ft. apart with spaces between them filled with sand over which 1¾ in. yellow pine flooring is nailed to the strips covered with roofing felt and finished with 1¼-in. dressed tongue and groove white oak flooring.

The ground flooring of the shop is made with a 6-in. bottom course of broken stone laid on the carefully levelled surface of the earth and covered with 1 in. of sand and tar on which are laid 3x4-in. transverse nailing strips treated by the zinc process. The spaces between the strips are filled with clean dry sand and covered with 2¾-in. longitudinal boards, a course of roofing felt and a final finished floor of transverse 1¼-in. white oak planks. A portion of the floor in the centre of shop is formed of sheet asphalt.

The riveting tower is 77 ft. high and one panel or 26 ft. long and extends across one of the side aisles. It is divided into five vertical panels by three horizontal longitudinal lattice girder struts and one plate girder in each side, and the three upper panels are X-braced with turnbuckle rods 1⅜ in. square. The plate girders about 60 ft. above the floor are 30 in. deep with 4x3-in. flange angles and will serve to support the runways for the girder cranes to be hereafter installed to carry the boilers over the riveting apparatus. The tower has a special pitched roof carried by longitudinal triangular trusses and the walls are provided with four tiers of windows and sheathed above the roofs of the side aisle with corrugated iron.

This building was erected by means of a two-boom traveler, assisted by a wrecking derrick. The traveler had a boom about 75 ft. long. Two tracks were laid under the main crane-runway and traveler set up at one end of the building. It was equipped with double flanged wheels, and traveled on two single rail tracks, one under each side of the traveler. Two engines were used and the building was erected bay by bay complete. In other words the erection commenced at one end, and the traveler backed away from its work. The tracks, of course, upon which it operated, were extended as the work progressed.

To facilitate the work, a wrecking derrick was used to unload the material, distributing same behind the traveler in the bays where it belonged and as the traveler reached these bays, it was a very simple matter to erect it. All of the riveting was done by hand.

The upper portion of the riveting tower was raised by means of gin poles, carried on the main structure.

The crane girders were delivered after the structural steel had all been erected. The two large cranes weighed about 50 tons each, the smaller about 25 tons. These were erected by means of gin poles, and the motor and fittings were also raised by the same apparatus. All of the crane girders were erected by the general contractors.

The 250x100-ft. smith shop is a one-story building 34½ ft. high to the top of the main roof, with brick walls and a tar and gravel roof supported by a steel framework. A large proportion of the sides of the building and of the 25-ft. monitor 7 ft. high, which is on the center line of the roof, is occupied by three tiers of windows, of which the lower ones have double weighted sash and the upper ones are arranged to be operated horizontally, as described for the main shop.

The transverse trusses, 25 ft. apart on centres, span the full width of the building, thus avoiding any obstruction from intermediate columns and are supported on wall columns 31 ft. 3½ in. high. The columns have rectangular cross sections made with two 18-in. built channels latticed and are connected by a line of longitudinal wall girders 2 ft. deep and about 20 ft. above the floor. They are anchored to the foundation piers with pairs of 2-in. vertical bolts engaging reinforced seats on both sides of the column base.

The roof trusses 12 ft. deep at the center and 10 ft. deep at the ends were shipped in four sections each and were assembled and riveted together on the ground before erection. The top and bottom chords are made with pairs of channels, latticed and the web members are vertical posts and zig-zag diagonals and single diagonals made with pairs of angles except for the end diagonals, which are made with four angles each.

The purlins are 12-in., 35-lb. channels seated on the top chords of the trusses at panel points and have 5x3-in. nailing strips bolted to their webs to receive the transverse roofing planks. Both top and bottom chords of the trusses are web-connected to the wall columns with vertical gusset plates field-riveted to the latter and the top chord channels project beyond the inner face of the columns forming jaws which engage it. No girder cranes will be installed in this shop, but provision is made for hoisting moderate loads or setting up jib cranes at almost any point. The bottom chords of the main trusses are made extra heavy with pairs of 12-in., 30-lb. channels calculated to support loads of 6,000 lb. at any point. Transverse rigidity is given to the chords by horizontal longitudinal struts of the same cross-section. The panels between these struts are X-braced with single horizontal diagonals made with single angles and with pairs of angles latticed, thus forming several sets of horizontal trusses which control the entire area of the building and distribute all crane stresses throughout the whole framework. The building was erected by wrecking derricks, and the field riveting was done by hand.

Power House of the Parsons Shops.

The 84 x 215-ft. power house is designed for an ultimate equipment of 3,000-h.-p. of water tube boilers, two-thirds of which are now installed, together with five electrical units with a total capacity of 1,000 k.w., and two air compressors, pumps and other apparatus.

The steel framework of the building is divided into seven 29½-ft. panels by eight main transverse bents, each having three columns, two main roof trusses and a monitor truss. The center row of columns are enclosed in a longitudinal partition wall dividing the building into two equal aisles, one of which is for the boiler room and the other for the engine room, both with main floors about 6 ft. above grade and a 10-ft. basement below.

Provision is made for the construction of coal bunkers over the firing floor, and runway girders for a traveling crane extend the full length of the engine room. The floor is of steel and concrete and the roof is of concrete reinforced with ferroinclave and waterproofed with tar and gravel. The structural steel is of simple design with rectangular columns and riveted roof trusses having horizontal bottom chords, slightly inclined top chords, and zig-zag web members made with pairs of angles back to back.

The locomotive shop contains about 1,800 tons and the smith shop contains about 260 tons of structural steel, which was fabricated by the Brown-Ketcham Iron Works, Indianapolis, at their shops at Huff, Pa., and erected by the Steel Stone Construction Co., Chicago. The general designs were made by Mr. G. R. Henderson, consulting engineer, New York. All construction work was executed under the direction of Mr. S. B. Fisher, chief engineer of the railway company. James Stewart & Co., of New York and St. Louis, were the contractors for the buildings.

A Coal and Coke Handling Machine.

A coal and coke handling machine is to be installed in the storage yard of the United States Steel Corporation, at Gary, Ind., by the Hamilton Mfg. Co., Columbus, Ohio, and is a modification of the pit car loader made by that company. It is designed to operate in a storage yard 100 ft. wide and of any length and will pick up loose material from any part of the yard and stack it 40 ft. high. It is also equipped to reload from the stock pile into cars when the product is to be removed. In both operations it has a capacity of 6 tons per minute. The cost of rehandling coal and coke is less than 2 cents a ton, according to "The Engineering and Mining Journal," and the machine requires no overhead structure or any construction besides the platform and track on which it operates. The machine consists essentially of a car running on an 18-ft. gauge track and carrying the mechanical equipment. There are two belt conveyors, one leading forward and upward to the car to be loaded or to the stock pile, as the case may be, and the other leading backward and downward to the material to be collected. The framework of the collecting carrier is hinged at the car and its outer end moves from side to side, sweeping up the material on a nose plate and delivering it to the belt. The machine does not leave its 18-ft. track, but the radial sweep of the collector is 50 ft. The whole machine can be moved forward and backward by its own power, and as both the gathering and delivering conveyors swing in a complete circle about the machine center, coal can be picked up from any point in the yard and delivered to any point within the limit of the delivery conveyor.

The Final Decision Regarding the Septic Tank Patents.

Decision of U. S. Circuit Court of Appeals, Second Circuit, in Cameron Septic Tank Co. vs. Village of Saratoga Springs; opinion written by Judge Lacombe.

This cause comes here upon appeal from a decree of the U. S. Circuit Court, Northern District of New York (see Engineering Record, March 30, 1907), dismissing a bill for infringement of U. S. Patent No. 634,423, granted Oct. 3, 1899 (on application filed March 15, 1897), to Donald Cameron and others for "Process of and Apparatus for Treating Sewage." The opinion of the Circuit Court is found in 151 Fed. Rep. 242.

The opinion below has quoted at great length from the specifications. Since it may fairly be assumed that no one is likely to read this opinion without also examining that of the circuit court, those voluminous excerpts need not be repeated here, although in the progress of this discussion it may be necessary to quote many passages from such specifications. There are two groups of claims: those for a process, and those for an apparatus. The subject of discussion may be best introduced by reciting the five process claims which are relied upon, as follows:

"1. The process of purifying sewage which consists in subjecting the sewage under exclusion of air, of light and of agitation to the action of anaerobic bacteria until the whole mass of solid organic matter contained therein becomes liquefied, and then subjecting the liquid effluent to air and light.

"2. The process of liquefying the solid matter contained in sewage, which consists in secluding a pool of sewage having a non-disturbing inflow and outflow, from light, air and agitation until a mass of micro-organisms has been developed of a character and quantity sufficient to liquefy the solid matter of the flowing sewage, the inflow serving to sustain the micro-organisms, and then subjecting said pool under exclusion of light and air and under a non-disturbing inflow and outflow to liquefying action of the so-cultivated micro-organisms until the solid organic matter contained in the flowing sewage is dissolved.

"3. The process of liquefying the solid matter contained in sewage, which consists in secluding a pool of sewage having a non-disturbing inflow and outflow, from light, air and agitation until a mass of micro-organisms has been developed of a character and quantity sufficient to liquefy the solid matter of the flowing sewage, the inflow serving to sustain the micro-organisms, then subjecting said pool under a non-disturbing inflow and outflow and under exclusion of light and air to the liquefying action of the so-cultivated micro-organisms until the solid organic matter contained in the flowing sewage is dissolved and then subjecting the liquid outflow to an aerating operation.

"4. The process of liquefying the solid matter contained in sewage, which consists in secluding a pool of sewage having a non-disturbing inflow and outflow from light, air and agitation until a mass of micro-organisms has been developed of a character and quantity sufficient to liquefy the solid matter of the flowing sewage, the inflow serving to sustain the micro-organisms, then subjecting said pool under a non-disturbing inflow and outflow and under exclusion of light and air to the liquefying action of the so-cultivated micro-organisms until the solid organic matter contained in the flowing sewage is dissolved, then subjecting the liquid outflow to an aerating operation, and then to a filtering operation."

"21. The process of liquefying the solid matter contained in sewage which consists in secluding a pool of sewage having a non-disturbing inflow and outflow from light, air and agitation until a thick scum is formed on the surface thereof and a mass of micro-organisms has been developed of a character and quantity sufficient to liquefy the solid matter of the flowing sewage, the inflow serving to sustain the micro-organisms, and then subjecting said pool under the cover of said scum and under a non-disturbing inflow and outflow to the liquefying action of the so-cultivated micro-organisms until all the solid matter contained in the flowing sewage is dissolved."

The apparatus for carrying on this process consists of a tank, constructed of any suitable material such as cement-concrete, shallow in comparison with its other dimensions, and in which the "pool of sewage" is located. It may be provided with an air-tight cover, for temporary use only, because after the tank has been in operation for two or three days a peculiar brown scum begins to form at the top and eventually becomes two or three inches thick and serves as an air-tight cover for the sewage. The pool which is secluded in the tank is secured against disturbance from inflow or outflow by having inlet and outlet so located and constructed that the sewage will flow through in a quiet manner. From the tank the effluent passes into an aerator where it is exposed to the action of the air and afterwards passes on to an ordinary filter bed. By reference to the claims it will be perceived that the second and twenty-first cover only so much of the process as takes place in the secluded pool; the first and third cover also the aerating operation; and the fourth adds the final filtering operation.

To a proper understanding of what the patent shows it will be necessary to postulate certain definitions.

Anaerobes are bacteria (micro-organisms) that are killed by air; they can neither act, multiply nor even exist in contact with free oxygen. They are also called the germs of putrefaction.

Aerobes are bacteria that die without air or oxygen. They are also called the germs of oxidation or of nitrification, and their action is often called decomposition or fermentation.

That both these families of bacteria are potent in breaking up the solid parts of sewage matter was a fact long known to those skilled in the art. The patentee introduced a new word to the art—*Septic;* he calls his tank a septic tank. Defendant's expert concedes that the term was first used by Cameron and applied to the tank which he constructed and put in operation at Exeter, England. However, this word may have been used subsequently by others, it should in construing this patent be given the meaning which the patentee gave to it. Examination of the specification and claims shows that the definition contained in complainant's brief is in accord with them.

Septic action is the action of a colony of anaerobes preventing the accumulation of solids, unhampered by the presence of aerobes or oxygen or agitation.

The *septic* tank is the home and workshop of such anaerobic colony and its structural characteristics, as distinguished from other tanks, includes the roof of septic scum which is built by the anaerobes over the sewage current and remains as a permanent part of the tank.

The essential features of Cameron's process are these: He secures separate and successive action of anaerobes and aerobes on the organic matter of the solids in the flowing current of sewage. He first sets the anaerobes to work under such conditions that whatever aerobes were present in the flowing current as it enters the anaerobes' workshop are quickly destroyed, because without air or oxygen they cannot live, and at the outflow end of his septic tank there is absolutely none; tests mark free oxygen as zero. He cultivates this colony of anaerobes under conditions most favorable for their growth and activity, eliminating light, air and agitation while the slowly moving current is exposed to their activities. There is some oxygen present when the sewage flows in, although it has all disappeared before it flows out; and the current is not completely at rest, it flows in a quiet manner —were it stagnant the desired bacterial action would be disturbed and retarded. But there is a substantial absence from the current of oxygen and agitation. A curious result of setting the anaerobes to work under such conditions, after the septic scum has formed is pointed out in the specifications. "The micro-organisms increase at a fabulous rate, being fed by the incoming solid matter of the sewage until a mass of bacteria is developed sufficient to liquefy substantially all the solid organic matter contained in the sewage passing through the pool; . . . and the outflow is in the form of a liquid without solid particles of sewage. . . . The liquefied sewage as it leaves the septic pool has a slight odor, . . . and to relieve it of this slight odor it is subjected to an aerating operation." It is contended by the complainant that such effluent is peculiarly adapted for further treatment on a filter bed.

Thus treated the colony of bacteria is continually recruited from incoming solid matter, maintaining such numbers as are sufficient at all times quickly to transform the sewage solids and the wastes of bacterial energy into a liquid effluent. This action is thus described by one of defendant's experts: "In my opinion from six to eight weeks is required in which the liquefying action will be established to the extent of creating an *equilibrium* beyond which the solids will not accumulate on the bottom of the tank or on the top thereof; . . . an equilibrium between the accumulated solids in the tank plus those being constantly added thereto by the inflow of the sewage, and the bacterial activities whereby further accumulations are prevented." Moreover, as the patentee states, "by this invention crude sewage can be treated for long periods without practically any sludge at all forming in the tank." In the plant at Saratoga, which treats sewage by the process above described—infringement of these process claims is not denied in defendant's brief—"the tanks have never been emptied since they were put in service, July, 1903, a period of 2½ years, and no solid matter has been taken from them." In consequence this equilibrium between the solids and the solid-destroyers, when once established, need not be disturbed, it will continue indefinitely. Having passed his sewage through the secluded pool, where it was exposed to anaerobic action only, it is aerated and then subjected to aerobic action.

It is this method of dividing the process which complainant claims to be novel. Of its essential features the experts for complainant point out that *separate* action is necessary because the anaerobes cannot successfully act in conjunction with the aerobes which are inimical to their multiplication and even existence; that *successive* action is necessary because the anaerobes prepare the organic matter for succeeding purification by the aerobes; that the flowing current is essential because it makes a continuous process, takes the matter out of the way of the anaerobes as fast as they are through with it and prevents the formation of toxins which would impair the value of the anaerobic produce for the purifying action of aerobes.

That the process possesses utility is beyond dispute; it eliminates the problem of removing "sludge," the solid matter which accumulates in the bottom of some sewage tanks and the disposition of which is often troublesome. Moreover, the defendant uses it and thus practically concedes that it is useful.

The process which has been described is the process which the patent indicates. The trial judge, however, reached the conclusion that the statements of the patent constituted a misdescription. He says:

"The patentee declares 'The invention consists in certain methods of developing in a *flowing current of sewage* bacteria capable of dissolving the mass of solid organic matter contained therein and of subsequently utilizing the so-developed bacteria in liquefying the mass of organic matter contained in the flowing current.' If this means what it says nothing of the kind is done. The bacteria or micro-organisms are not developed in the *flowing current of sewage* and cannot be effectually. They are developed in that part of the sewage which is at rest and which has been brought to a 'stand still' secluded in a pool and which must remain at a 'stand still' below the flowing current until the bacteria are developed and have actually liquefied it."

In our opinion this is error and we believe the trial judge was misled by a diagram introduced by the complainant and made quite prominent in the argument. It gave us a misconception of the so-called septic action until in the course of the hearing it was corrected by counsel. It is an illustrative diagram showing the Cameron tank, shallow in comparison with its other dimensions, with inlet and outlet arranged so as to avoid agitation; arrows at inlet and outlet mark the direction of the flowing current. It displays shaded portions at top and bottom of the contents of the tank, representing the surface scum and the deposit. Such shaded portions occupy more than one-half the entire depth and are of about equal thickness at top and bottom. This is wrong because the evidence shows that the total solids, when condition of equilibrium is established, vary between 20 and 25 per cent. of the total depth, and the scum is only a few inches in thickness—the total depth being about 8 ft. The diagram further displays a succession of wavy lines from top to bottom towards the center, each terminating in an arrow-head before reaching the center; they would seem to indicate the existence of a neutral zone of flowing current between them, in which whatever action the arrow-headed lines indicate does not take place. The condition of things indicated by this illustration diagram is in accord with Judge Ray's description above quoted, but is not in accord with the testimony.

The evidence as to what takes place in the septic tank of the patent is exceptionally persuasive. It appears that when Cameron announced his process to the world and built his tank at Exeter to put it in practice, he at once challenged the attention of the art. Sewage experts in England and elsewhere discussed his contribution as a startlingly novel one, and some of them came to Exeter to study its workings. In order to facilitate such study a glass inspection chamber was constructed in the tank, wherein an observer might place himself and, through its transparent walls with the aid of a lamp, study the process which was going on. One of complainant's experts made observations from such chamber and has testified to what he saw. Without indicating specific quotations it may be stated that the conditions within the septic tank are as follows: The deposit consists of a black peaty matter apparently solid at the bottom but gradually merging to a lighter or more mushy or frothy consistency on the upper strata. The upper surface of the scum is a brown leathery substance, immediately underneath it somewhat resembles axle grease, grading off to a mushy substance beneath. The current flowing between the sludge (deposit) and the scum consists of an already liquid portion in which are suspended particles of organic matter which because of their specific gravity remain suspended in the liquid and flow therewith. In this liquid portion also are particles which are detached by the anaerobic action from the floating or settled solids, and which particles cross the liquid in an interchange from top to bottom, or from bottom to top. The arrow heads in the illustrative diagram indicated these particles but did not show them *crossing* the liquid. This interchange is constantly going on, each particle flowing a certain distance with the current at each crossing, each particle being more finely divided at each successive crossing until it is finally merged in the liquid.

The expert who had occupied the inspection chamber thus sums up the contention of complainant. "Every particle of solid organic matter suspended in the liquid current of the septic tank finds itself closely surrounded by anaerobes already cultivated in the scum and sediment and completely at their mercy, because every other influence is excluded by the 'exclusion of light, air and agitation' which the patent so frequently repeats. Its liquefaction therefore does not have to wait for the cultivation of anaerobes, but commences immediately and proceeds with great rapidity. Afterwards the liquefied particles find the aerobes all ready for them in the filter, where they in turn have full sway and oxidize and nitrify them, thus completing the purification. The complete separation of the anaerobic and aerobic actions is still further emphasized in the Cameron process by interposing between them the aerating operation, the action of which is to eliminate all the remaining traces of the anaerobic operation in the septic tank which might interfere with the aerobes."

It is not necessary to cite the evidence which complainant's counsel has collated to show that the action takes place in the septic tank—"the workshop of the anaerobes"—*is* correctly set forth in the patent. One of defendant's experts, not incidentally, but in a carefully phrased answer to a specific question, says: "I believe further that the action (anaerobic) which, as I have stated, nearly always in my opinion has already begun before the solids have reached the tank, is *continued in every portion* of the tank both in the surface scum and the bottom deposit and *in the liquid contents.*" Our attention has been called to nothing in the record which controverts or qualifies this admission in any way and it must be accepted as true.

The question of anticipation is greatly simplified by a clear understanding of precisely what the Cameron process is. The crux of the question is stated in complainant's brief as follows: "In all processes of the prior art the aerobic or oxidizing action was continuous from the time the matter left the house as house-waste until the end of its purification as sewage. Cameron's separate anaerobic colony was the first break that was ever made in such aerobic action." It is not disputed that anaerobic action was present to a greater or less extent in prior processes, but it is contended that Cameron was absolutely the first to instruct the art that the problem of removing sludge could be practically eliminated (irrespective of securing other advantages) by providing the anaerobes with a workshop in which they might act upon the solid contents of the flowing current, unhampered by the presence of air, oxygen, agitation or aerobes. With the question so closely limited the burden of comparing prior patents and publications with the Cameron process is materially reduced.

The process which, apparently, has been most relied on as an anticipation is that of Louis Mouras, who took out a French patent Sept. 22, 1881 (No. 144,994), an English patent (in the name of W. R. Lake) No. 5391 of 1881, and a patent in this country Nov. 28, 1882 (No. 268,120). A study of these patents discloses what it was that Mouras contributed to the art. He did not undertake to treat the sewage of a system of sewers at the purification end, but to provide at each individual building a cesspool or scavenger for preparing the house-waste before it passes on to the sewer. His tank or scavenger might be of any form or any kind of materials, its inlet and outlet pipes are to be located below the surface of its contents, and the tank hermetically closed so that the outer air cannot enter the tank. The tank does not begin to operate until it is completely full of water. If then there is let in through the receiving pipe any volume whatever of water or feces, immediately an equal volume of water is expelled by the discharge pipe; the "discharge pipe never passes anything but turbid water hold-in dissolution (in the English and American patents the phrase is "holding in suspension or solution") a certain quantity of matter coming from the decomposition and disaggregation of matter going on at the bottom of the tank." By flushing the tank, as pointed out in a later quotation, it is cleansed without having recourse to the usual means of cleansing.

Mouras says nothing about any bacterial action, but undoubtedly there was in his tank, as in all sewage tanks, some anaerobic action going on. That he made no provision, however, for securing conditions favorable to the action of the anaerobes, nor for separating their field of action from that of the aerobes is manifest from the directions he gives as to operation—directions wholly incompatible with the exclusion of oxygen and of agitation upon which Cameron insists. He says: "For the proper working of the apparatus it is expedient to discharge into the receiving pipe, as much as possible, rain water and dishwater; in short, all water that can be disposed of, in order to facilitate in the tank the decomposition and disaggregation of feces and all other decomposable matters which may chance to be there. . . . It will happen even in heavy showers, that the current occasioned by the falling water will produce an eddy which will make itself felt at a great depth in the tank, and which will expel from it, by the discharge canal, a great quantity of matter in dissolution, so that the cleansing of the tank will be accomplished up to the height of the eddy. (Manifestly this is a macerating process.) Furthermore, if the shower lasts a certain time, nothing but clear water will come out of the discharge pipe." The tank has been simply flushed out. The promotion of this agitation and formation of eddies is facilitated by Mouras' directions to bring in the inlet pipe perpendicularly.

Whether or not the object of this copious supply of water was to supply oxygen, such undoubtedly was its effect. It is not disputed that fresh water brings with it free oxygen. "Dilution," says one of defendant's experts, "consists in bringing the sewage into contact with a sufficient quantity of fresh water so that the dissolved oxygen which such water always contains can promote bacterial action. . . . Up to a certain point with an admixture of fresh water enough dissolved oxygen is available for the purpose." Elsewhere he says "aerobic fermentation will take place in sewage to the exclusion of anaerobic so long as the supply of oxygen is present." As we have seen the only bacterial action which oxygen promotes is that of the aerobes; to the anaerobes it is a handicap and, in sufficient quantities, fatal. That oxygen is present in the Mouras tank is further shown by actual tests of tanks built, as defendant admits, according to the teachings of his patent; at their outlets it was found in large and varying quantities while at the outlet of the Saratoga plant, built according to Cameron's teachings, there was none. The cesspool, therefore, described in the Mouras' patents differs materially from that described by Cameron, since it discloses no workshop for anaerobes separated from the aerobes and maintained in anaerobic condition by the careful exclusion of oxygen and agitation.

Besides the three patents above cited, there is a mass of Mouras literature in the record, consisting of the observations of text-book writers and newspaper men upon his apparatus and process. The articles most relied upon in argument are those published in a periodical called "Cosmos," by a French abbe, one F. Moigno, who describes himself as "one of the common herd," quotes from Deuteronomy and two of the Evangelists and announces the invention of M. Mouras as "a complete solution of the problem, which for centuries had been an insolent menace hurled in the face of all humanity." He conjectures that "in the heart of the scavenger, the great agent of dissolution, of liquefaction, would be hydrosulphate of ammonia or one of its congeners; "or may it not be the vibriors or anaerobic bacteria which are destroyed by oxygen and which manifest their destructive activity only in vessels from which the air is excluded." Of all these publications it is sufficient to say that, so far as they correctly describe the process which Mouras indicated, they point out only a tank in which aerobic action takes place, accompanied in some measure, in the deeper parts of the pool, by anaerobic action. So far as they contain suggestions, which Mouras did not indicate, they are (in the language of the Supreme Court in Seymour v. Osborne, 11 Wall. 555) "mere vague and general representations. . . . (not) sufficient to enable those skilled in the art or science to understand the nature and operation of the invention and to carry it into practical use." We find in them nothing to indicate that by changing Mouras' inlet so as to avoid agitation, by eliminating his large influx of fresh water with the eddies and the oxygen which is brought, one could establish a separate workshop for the anaerobes, and by that change modify the Mouras process with beneficial results. None of them present "an account of a complete and operative invention capable of being put into practical operation," by establishing purely anaerobic conditions in a septic tank and maintaining them till an equilibrium was established which would permit an indefinite retention of the solids. Nor is this conclusion the mere inference of one unskilled in the art; this Mouras literature was published in the early eighties, but no septic tank such as Cameron describes was built until his first experimental structure was set up at Exeter in 1895.

The next reference is to the patents and work of Scott-Moncrief and of Dibdin which, as complainants admit, are the nearest approach in principle to Cameron because they contemplated utilizing anaerobes and announced that "there is no need for the same amount of oxygen as has hitherto been believed to be necessary." But they fall short of Cameron's process, since they did not provide for having the anaerobes cultivated and worked separately from aerobes, oxygen and agitation. Two quotations from the Scott-Moncrieff U. S. Patent (530,622) are sufficient to demonstrate this statement. "Sludge or deposit (which merely represents that portion of the organic matter which the organisms have not had time to liquefy) . . . may be removed from the concentrating compartment, B, when required by simply opening the penstock and raking out or flushing." The agitation resulting from such an operation would destroy the septic conditions, which it takes weeks under the Cameron process to produce, and which if left undisturbed would continue indefinitely. "In order to provide for the . . . aeration of the filtering material without stopping the continuity of the treatment . . . I provide a pumping apparatus as shown at R. . . for forcing air into the liquid contents of the filter at work . . . so as to supply oxygen to the organisms when necessary or advisable." Dibdin, in his Report to the London County Council says: "Firstly, the organisms must be supplied with plenty of air." But it is the distinctive teaching of the Cameron process that anaerobic conditions must be maintained in his septic tank and since oxygen is fatal to anaerobes he states in his patent that "it is of the utmost importance that means be provided for preventing contact with the air," while every one of his process claims include a *pool secluded from air*.

The next reference is to a German patent to Muller (9,793 of 1878). His process is mainly intended for disembarrassing beet-sugar works from liquid waste; he says it may with slight modification be applied even to the treatment of household slops in towns. The only passage in the patent which is at all relevant reads as follows: "Whereas the former disinfecting methods had for their essential object to obviate as far as practicable any phenomena of putrefaction, corruption or decomposition, the process herein described, on the contrary, aims at the methodical cultivation of those small 'leaven-like' organisms to the viability of which modern science has traced the so-called 'self-unmixing' processes, namely acidification, fermentation, putrefaction, decay or the like, in accordance with the rules of physiology, with a view to bringing them into requisition in the task of precipitating out the liquid waste-substances or bringing about their complete mineralization (i. e., reduction to simple inorganic compounds)." . . . "Only in very few cases will it be necessary to actually sow the seed of these 'leaven-like' organisms; they will mostly develop in amply sufficient quantities from the numberless germs in suspension in the atmosphere which are at all times ready to settle or 'colonize' in a suitable soil, while their growth is further induced by the organic admixtures which are added for the purpose of supplying an adequate proportion of nutritive substances, in the form of meat, blood, glue, gluten or human excreta, etc."

From the enumeration "acidification, fermentation, putrefaction, decay or the like," it is apparent that Muller had in mind both groups of bacteria, for the result of aerobes' activity is fermentation, and the results of anaerobes' activity is putrefaction. Indeed the last quotation referring to germ colonization with atmospheric surroundings would seem to indicate that it was the aerobes which he expected to colonize. The description of his process is even more vague than the preliminary statement. There are no drawings but, since he directs the use of three or four basins of at least one metre's depth, provided with a floating top-cover of porous material such as straw, etc., it is manifest that his patent did not suggest the establishing of anaerobic conditions in a septic tank.

The English patent to Adeney and Parry (3,313 of 1890) provides for keeping "the liquor (sewage) to be treated under suitable conditions for the rapid multiplication of micro-organisms." But they point out three methods only, one by chemical treatment, the other two by thorough aeration for the "purpose and object of developing and multiplying the micro-organisms in the sewage"—which certainly is not Cameron's process.

Besides the patents and literature above referred to defendant contends that anticipation is found in certain tanks which were built and used for sewage purification in this country prior to Cameron's date of invention. So far as their structural details are concerned, some of them at least closely resembled Cameron's apparatus; having the shallowness in comparison with other dimensions and inlet and outlet so arranged as to reduce the amount of agitation. Without stopping to consider some minor criticisms which complainant's counsel makes on these alleged anticipations, we may dispose of them in two ways. Tests for oxygen were made at all such as were still in operation when the testimony was being taken with the result that there was found at the outlets free and absorbed oxygen in quantities varying from 24 to 45 per cent., while at the Saratoga plant, embodying the Cameron process, the record for oxygen at the outlet was zero. It further appears from the testimony that of these tanks those most resembling Cameron's were all cleaned and the sediment on the bottom removed, some of them frequently, some once a month, the one most relied upon "at least seven times per year and probably oftener." When it is remembered that all the experts on both side agree that it takes from six weeks to two months to produce the anaerobic conditions which Cameron prescribes for his septic tank, with the scum and deposit of the proper thickness and the condition of equilibrium established which admits of an indefinite retention of the solids, it is quite apparent that these are not Cameron septic tanks; the prescribed conditions are swept away by the hands of the cleaner before they reach practical efficiency. On the contrary at Saratoga there has been no removal of sludge, and, therefore, no destruction of septic conditions for two years and a half.

Reference has been made to opinions in the first circuit in American Sewage Co. v. City of Pawtucket 132 Fed. Rep. 35; 138 Fed. Rep. 811; 146 Fed. Rep. 763. Inasmuch as that litigation related to a different patent (U. S. 559,522 May 5, 1896, to Glover) the validity of which was not disputed, and the record before the courts in the first circuit was different from the one presented here, we do not find those decisions helpful to a conclusion upon the questions raised in the case at bar.

It is further contended by defendant that these five claims are void because the process they cover "is a process of nature and one which cannot be covered by any one." As we have seen before the distinctively novel feature is the septic tank or separate workshop for the microbes. The circuit court, influenced, as it seems to us by the conclusion which it reached that Mouras and Moigne disclosed all that Cameron claims, decided that the process claims could not be sustained, citing O'Reilly v. Morse, 15 Howard 62, and other cases. We, however, are satisfied that Cameron was the first one to subject a flowing current of sewage to the action of anaerobes and aerobes under conditions which secured their separate and successive action, the action of the segregated anaerobes fitting the effluent for subsequent filtration and aerobic action; and by reason of such careful segregation he was the first to secure such specified condition in the anaerobic colony that its capacity for its natural work had increased to such an extent that it became capable of disposing of practically all future inflowing sewage that entered its workshop without accumulating such a deposit of sludge as would require removal. This certainly involved "the use of one of the agencies of nature for a practical purpose." Risdon Locomotive Works v. Madert, 168 U. S. 77. The process is one which puts a force of nature into a certain specified condition and then uses it in that condition for a practical purpose. Bell Telephone, 126 U. S., 534. Within the principles enunciated in the two cases last cited we are satisfied that Cameron's process as set forth in these five process claims is patentable. Infringement is not disputed.

The Apparatus Claims.—These are Nos. 5, 6, 7, 8, 11, 12, 20 and 22; infringement is denied of 6, 7, 8 and 12. It is not necessary to quote them, they are set forth in the opinion of the circuit court: each one of them contains as an element of its combination "a septic tank." Speaking generally and disregarding some minor variations of detail, it may be said that the several structural elements of each combination are old and that tanks with covers and with inlets and outlets arranged so as to avoid agitation were not broadly new. The contention of the complainant is this. Cameron introduced the word septic into the art, he defined it and it is used in the claims with the meaning he gave it. The septic tank, therefore, of these claims is the septic tank in which the septic scum and deposit are found, in which the equilibrium above referred to is established and in which the solids may be indefinitely retained. This is a peculiar structure, produced in part by the hand of man, in part by the forces of nature. After the labors of the mason, the plumber, and the iron-worker are over the micro-organisms are set to work, and in the course of from six weeks to two months they add an inside floor and a roof of scum to the masonry structure, whereupon its temporary iron cover may be discarded and then for the first, we have the septic tank of the claims. And because in the prior art there is no masonry (or other) structure which has been thus improved and modified by the action of anaerobic bacteria, this single element of "a septic tank" is sufficiently novel to uphold each combination into which it enters.

The question presented is a most curious one; nothing analogous is found in any authority to which we are referred. The argument is ingenious and forceful, but in this case we do not find it convincing. The tank of the apparatus is, as the specifications state, "a suitable tank for carrying out (the) invention," i. e., a tank suitable for the colonization and cultivation of the anaerobes so that they may in time reach the stage of equilibrium with the solids. The apparatus claims were never, in our opinion, intended to cover any tank other than that which Cameron's human workmen built. And this opinion is fortified by the following excerpts from the specifications. "(The sewage) then passes through . . . the inlets into the tank A, in which it may be treated either chemically, bacteriologically, or otherwise, as desired; but it is preferable to treat it bacteriologically." "The invention also relates to a special form of tank in which a liquid is to be treated for the removal of solid matter by subsidence, flotation or otherwise. . . . This form of tank is illustrated in Figs. 4, 5 and 6. . . . In the arrangement shown in (these figures) the sewage or other liquid . . . passes into the tanks A, where as in the previous arrangement, it may be treated either chemically, bacteriologically or otherwise, as desired." We concur with the circuit judge in his conclusion as to these apparatus claims.

The decree is reversed without costs, and cause remanded to the circuit court with instructions to decree in favor of complainant upon claims 1, 2, 3, 4 and 21, and in favor of defendant as to claims 5, 6, 7, 8, 11, 12, 20 and 22, without costs.

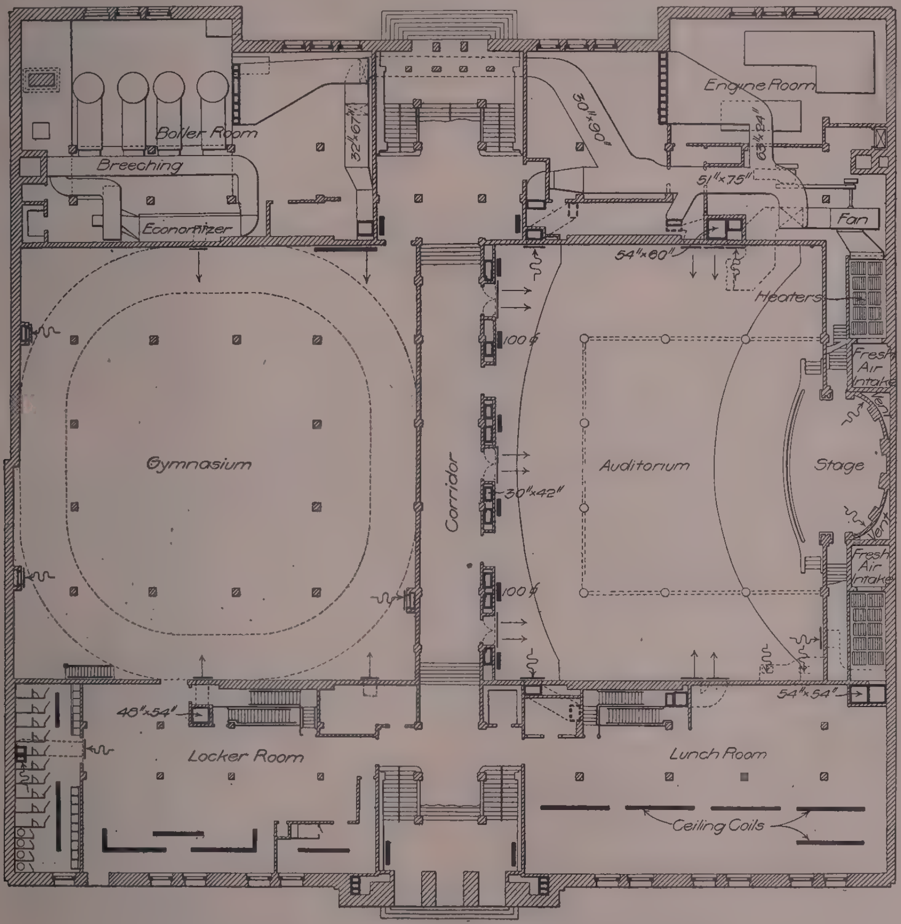
Street Cleaning in Washington, D. C., during 1906-1907 is described in detail in a report by Supt. J. T. Twohey, of the Street Cleaning Department. The total area of paved streets cleaned by hand during the year was 497,811,216 sq. yd., and the number of men employed on hand patrol work was 189 to 215; 39,952 cu. yd. of debris and 56,292 bags of paper were removed. The cost of cleaning per thousand yards was 18.2 cents. This is an increase of 0.004 cent per thousand yards over the cost of the previous year, the increase being due primarily to the longer haul made necessary by the closing of two of the public dumps that had been filled in. To keep the streets and sidewalks free of paper during the daytime, the men spend an average of two hours on nothing but picking it up. They are required to go over their respective sections four times per day and each trip takes about one-half hour. In addition to this work at stated intervals the laborers are also expected to pick up any such material within reasonable distance while sweeping. The total area of paved streets cleaned by machines during the year was 373,029,844 sq. yd., and the amount of debris removed reached a total of 86,814 cu. yd. The contract price for this work per thousand square yards was 22¾ cents.

Mechanical Plant of the Stuyvesant High School, New York City.

Part II.

The new Stuyvesant High School, recently completed on East 15th and 16th Sts., near First Ave., New York City, the power plant and mechanical equipment of which were described in the preceding issue, contains a total of 86 class-rooms, laboratories and shops for manual training, exclusive of the large auditorium and gymnasium in the basement, each of which is approximately 90 x 100 ft. in size. The total cubical contents of the building is about 2,500,000 cu. ft., of which approximately 2,080,000 cu. ft. is above the basement. The building has been planned for a total class-room capacity for pupils of over 3,000 exclusive of the auditorium and gymnasium facilities, the gymnasium accommodating about 200 pupils at one time and the auditorium having a seating capacity of approximately 1,700. For reason of this large occupancy, ventilation has been made an important feature of the building's equipment, and it has, moreover, been rendered independent of heating in all parts of the building, excepting the auditorium. The heating system which utilizes direct radiation operated on the two-pipe system with low pressure steam and vacuum returns, is extensive, embracing nearly 41,000 sq. ft. of surface for the entire building, of which approximately 32,000 sq. ft. is above the basement.

The direct radiation was proportioned in the various parts of the building on the thermal unit basis of heat loss, modified to suit the use of large reversible sash, and the radiating units are given the usual locations under window areas. Radiator units of both the sectional cast-iron type and pipe coils are used, the latter especially where limitations of space in the laboratories and shops made the economy of room thus secured, desirable, and in certain of the wardrobe rooms. Extensive use of ceiling coil radiation is also made in a number of the laboratories, lunch rooms, etc., in which the floor space is thoroughly occupied by desks, tables and apparatus, and of sky-light radiation, there being over both the auditorium and gymnasium at the base of the light and ventilation courts, groups of nine sky-lights, each 12 ft. square. The pipe coils are formed of straight 1¼-in. pipes with headers or close return bends, mounted on stands of 2 x ¼-in. strap iron, those for floor mounting being supported on floor and braces between base board and chair rail, while the ceiling coils as used in the toilets and laboratories are of the mitre pattern suspended upon sections of 1¼-in. pipe bolted to beams embedded in the ceiling construction. The sky-light coils are in all cases coils built up two pipes high and mitred horizontally within the sky-light enclosure above the roof, the pipes having supply and return connections at one end of the coil and a close return bend at the other. The direct radiators are of the Vestal form supplied by the American Radiator Co., for all radiation of the floor type, which is installed in two heights, namely 32 and 39 in., as required by the height of the window sills, and the Colonial wall radiators where this type of radiation is required.



Plan of Basement of Stuyvesant High School Building.

Steam is supplied to the direct radiation by 64 riser lines that are carried up from the low pressure heating mains in the basement and first story to the radiator connections following the usual arrangement of distribution along the outer wall lines. They vary in size from 1½ to 6-in. at the basement supply connections, the sizes above 4-in. occurring principally, however, where a number of risers on the upper floors are grouped into a single line through the lower floors, as above the gymnasium and auditorium spaces, and all lines are supported by iron clamps to the building construction at the second floor level. All individual risers have outlet connections at every floor, all of the lines reducing to 1¼, 1½ or 2-in. pipe at the upper ends. A special feature of the installation of risers is their concealment in all public portions of the first floor and of the auditorium and gymnasium, behind partitions or in closets or auxiliary rooms, while in all other portions of the building they are run exposed, and finished with the special insulating covering adopted. All of the risers above the basement are covered with three layers of heavy asbestos air cell covering, with resin paper wired over same and an outside protection or casing of galvanized iron neatly formed; in the basement and sub-basement these lines and their connections are covered with one inch standard asbestos moulded covering and an outside protection of resin paper and 8-oz. canvas.

The low pressure heating supply mains are, due to the peculiar layout of the basement, arranged in six divisions, exclusive of the supplies to the heating stacks of the ventilating systems, one for either side in front on the 15th St. side, two in the middle and one each for the two corners on the 16th St. front. The two divisions supplying the westerly side toward the 15th St. front are 7-in. lines which originate in the section of the exhaust steam main in the boiler room, while those supplying the westerly and easterly corners on the 16th St. front are respectively 6 and 7-in. lines which receive steam from the same exhaust line. The two divisions, however, which supply the easterly side toward the 15th St. front are each 6-in. mains which receive steam from the auxiliary exhaust lines in the sub-basement under that corner of the building, as stated in the preceding article descriptive of the power plant of the building; this auxiliary exhaust line while not connected to the main exhaust line of the power plant in the other portion of the building, has a supplementary supply through a reducing valve from the high pressure steam system so that a continuous supply of low pressure steam is available in case the fan engine in the sub-basement be shut down. Each of these divisions of the main, have supplementary live steam connections from the high pressure mains through 4 x 8-in. Kieley pressure reducing valves, which connections are fitted with by-passes and also safety valves for protection against possible excess pressure.

These heat distributing mains are for the greater part carried exposed on the ceiling of the basement but in locations carefully chosen to avoid appearance in any part of the corridors or public spaces. They are graded with the flow of steam for drainage of condensation and the branch connections supplying the riser lines are made in a novel manner, as shown in an accompanying sketch, in order to ensure free drainage; the branch supply outlets are taken off through 45-deg. downward connections to a reducing tee at the base of the riser, below which is connected a sediment pocket with branch to a vacuum valve on the return system, through which condensation from the main, as well as from the riser, is freely drained. An important feature of the supply connections to the risers is the use of diaphragm motor valves in the connections from the mains for over one-half of the steam supply risers, with connections for their control from a central operating board, by means of which fully one-half of the radiation in the building may be shut off with great facility in mild weather or in the middle of the day when less heating may be required. The motor valves are the standard Johnson diaphragm valves, as used for the control of radiators, and are located in the bases of the risers immediately above the sediment pockets in addition to the globe valve as shown in the accompanying sketch. These valves are operated with air supplied from the temperature regulation system, air lines being run from each valve to a control board located in the boiler room, on which are placed the 3-way cocks for the control of each valve. The valves are operated in the usual manner from here by admitting pressure for closure and releasing the pressure for opening the valve.

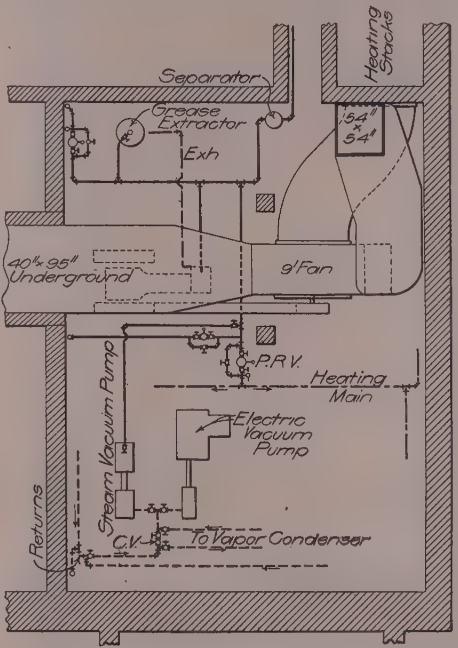
Temperature regulation is provided for in all parts of the building by an equipment of Johnson apparatus for radiator control. There is one thermostat placed in every class-room and two or more thermostats in each of the larger rooms including the shops, the drawing-rooms, the laboratories, the auditorium and the gymnasium, which control each of the heat sources in these rooms. The thermostats and the radiator control valves are of the usual Johnson construction, operated with compressed air at 15 lb. pressure, which pneumatic supply is furnished by a duplex steam compressor and a hydraulic air compressor in duplicate with large tank for air storage. The hydraulic compressor is operated with water supplied from the street service mains with pneumatic valves for automatic regulation of pressure. The tempering stacks of the ventilating systems are controlled from independent thermostats for each section, which are placed in the hot-air delivery ducts and adjusted for varying temperatures between 60° and 75° Fahr.

As the radiation is operated on the two-pipe system, the entire system of supply mains and risers is paralleled by a system of return risers and gathering mains, into which the radiation discharges condensation through vacuum valves. For the purpose of insuring perfect circulation and preventing back pressure at the turbine and engine exhausts, the returns are operated on the vacuum system, for which the Cryer return line system controlled by the Cryer Return Line System Co., New York, is used. All radiation discharges into the return lines through the Cryer vacuum valves which are tapped eccentrically into the radiator outlets for complete drainage of the condensation. The return branches to the radiators are all ¾-in. connections and grade downward toward the risers, which latter are lines ranging in size from 1 in. to 1½ in. at the top and increase to sizes from 1½ to 3½ in. at the base. The return risers all have sediment pockets similar to those of the supply risers, from which horizontal branches connect into the return mains through 45-deg. downward connections.

The condensation return gathering mains consist of a series of return pipes paralleling the division supply mains in the basement, which are carried to a pair of vacuum return pumps located in the lowest part of the site, namely in the sub-basement under the southeasterly corner of the building. The vacuum pumps consist of a 10 x 14 x 20-in. Marsh single-acting steam vacuum pump, which is bronze fitted for handling hot water and a 14 x 20-in. Knowles single acting vacuum pump of similar construction but arranged for electrical driving, being direct driven by a 10-h.-p. direct current interpole motor, supplied by the Electro-Dynamic Co., which is fitted for a speed variation of 4:1. At the connection to the pumps, there is a vapor by-pass taken off the return line and carried to a vapor condenser which is located in the intake chamber of one of the ventilating blowers, the purpose being to condense the vapor which may arise from the condensation returning. This vapor condenser is cast-iron indirect stack containing 240 sq. ft. of surface, which has 2½-in. connections to and from the main 6-in. return connection to the pump with a check valve between them, the weighted check valve insuring rapid removal of condensation from the vapor coil. The condensation is discharged from the vacuum pumps to an air separating tank in the boiler room at the opposite side of the building, in which all air and further vapor is removed, the condensation flowing by gravity to the Ferguson muffler tank and feed water heater for return to the boilers.

In addition to the low pressure steam supplied for heating purposes, live steam is delivered at reduced pressure to several parts of the building for use in the laboratories, lines being run to the chemical laboratories for the vapor baths and the water stills, to the wood working shops for use in the glue heaters, while to the mechanical laboratory, both high pressure and exhaust lines are run for the operation of a small experimental engine. The returns from the lines to the chemical laboratory and wood working shops are trapped into the discharge line from the vacuum pump for delivery to the air separating tank.

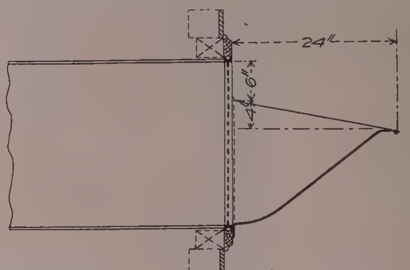
Ventilation.—The ventilation system of the building is extensive and complete, providing fresh air supply and exhaust ventilation in practically all rooms of the building, independent of the special ventilating systems which have been installed for the foundry and chemical laboratories in which obnoxious gases are produced. The ventilation, being supplied independent of heating throughout the building, is arranged for on the downward plenum system, the fresh air supply inlets in the various rooms being located near the ceiling line, while the exhaust openings are all located near the floor level, except in foundry cupalo room where this is reversed. The fresh air supply is operated by fan blast, two blowers being installed, which have an aggregate capacity of approximately 120,000 cu. ft. per minute, while the exhaust ventilation is accomplished throughout by natural draft, the vent registers connecting to wall flues which lead to ventilator hoods on the roof. The duct work and flue connections for ventilation are, owing to the irregular layout of the various floors, unusually complicated, the runs requiring considerable special ceiling and wall construction.



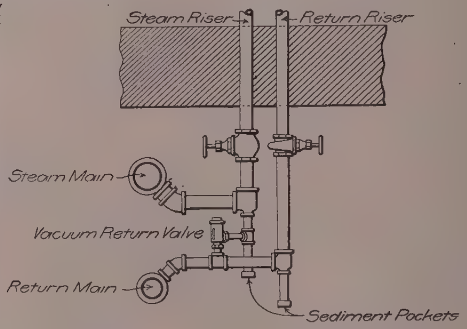
Plan of Apparatus in Sub-Basement.

Owing to the size of the building and the large capacity of fresh air required, the fresh air supply system was divided into two approximately equal parts, one covering the 15th St. half of the building and the other, that upon the 16th St. side. Each division is operated by an independent blower which is advantageously located near its distribution duct center, and were for convenience of intake connections, located on the easterly side of the building, one in the basement and the other in the sub-basement. The fresh air intakes are located on the easterly side of the building and consist for either division, of a vertical intake shaft of 9 x 10-ft. horizontal section that is carried up along the easterly wall to an intake opening at the base of the lighting and ventilation court on that side of the building. These shafts were, for convenience, arranged on opposite sides of the stage of the auditorium which occupies the basement and first story and have neither protecting hoods nor air filters in the connections to the heating chambers of the blower systems at their bases. The heating stacks are located in 9 x 20-ft. chambers, partitioned off in the corners of the auditorium on either side of the stage at the basement level and connect directly with the blower intakes at their outer ends.

The fresh air supply blowers each have 9-ft. wheels 52 in. in width, that for the 15th St. front half of the building having a special full-housed casing with top horizontal and vertical upward discharge outlets, while the other fan supplying the 16th St. division has a three-quarter-housing which discharges entirely into an underground duct connection beneath it. Each blower is belt driven by a horizontal center crank steam engine which is fitted with an adjustable governor permitting a speed range at the fan shaft of from 175 to 275 r. p. m. The engines operate with high pressure steam from the boiler plant and in the case of the engine on the 15th St. side has special connection for utilization of the exhaust in the heating stacks in the blower intake. The blowers have each capacity when operated at 200 r. p. m., of 60,000 cu. ft. per minute and deliver through the main duct connections from the discharge outlet at velocities of from 2,000 to 2,500 ft. per minute. Both the blowers and their driving engines were supplied by the B. F. Sturtevant Co., according to designs made by the Board of Education.



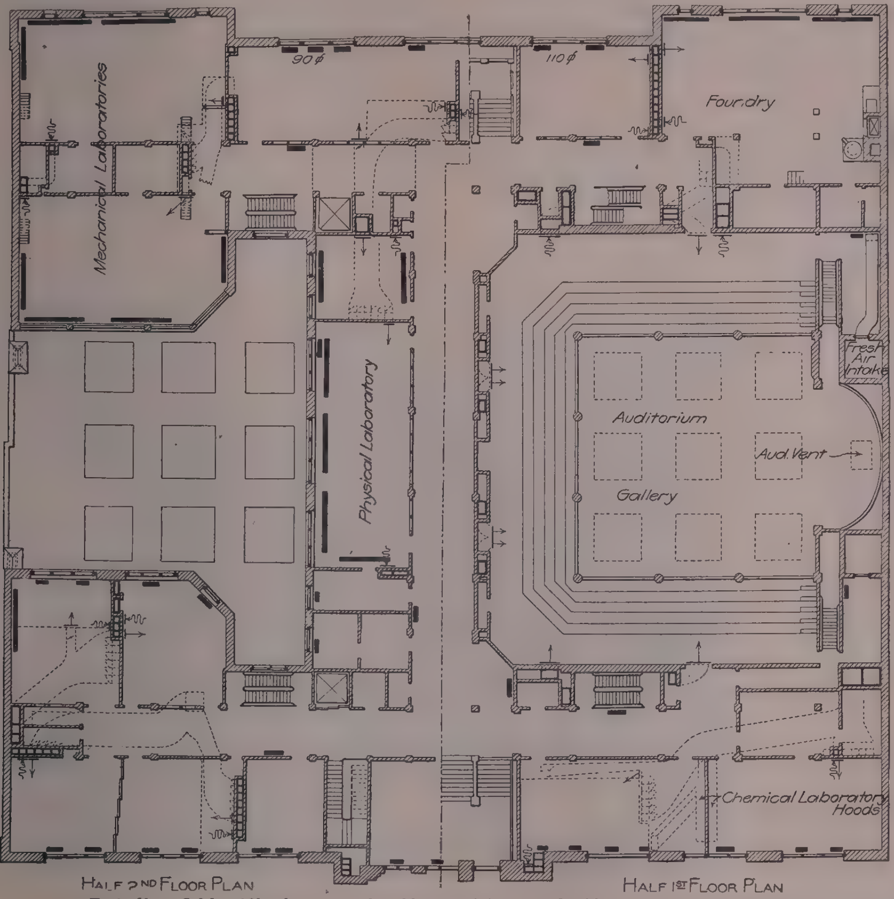
Deflectors on Fresh Air Outlets.



Detail of Riser Connections.

The delivery duct connections from the blowers of the two divisions are radically different owing to occupation of the basement on the 16th St. side by the mechanical plant which permitted of a ceiling arrangement of distributing ducts, while in the 15th St. side of the basement there are lunch and locker rooms which rendered it desirable to carry the distributing duct connections under the floor level. The blower supplying the 15th St. front side which is located in the sub-basement, has a horizontal connection to a 40 x 95-in. duct under the lunch room floor, which extends across the building, with side connections to auditorium outlets and ending in a 48 x 54-in. riser shaft on the opposite side, from which branch ducts furred in the first floor ceiling distribute the supply to numerous groups of individual wall risers to the various rooms served. The vertical up-discharge connection from this blower leads to a 54 x 60-in. riser shaft immediately above the blower, from which distributing branches are similarly disposed in furred ceiling construction above the first story level to groups of wall risers. The distribution duct system from the blower on the 16th St. side is much differently disposed, consisting of a galvanized iron trunk duct, 66 x 67½ in. in section, which rises from the underground delivery flue from this blower with branches carried on the basement ceiling to various riser connections. In this system a number of riser shafts of smaller section are carried up to the first and second-story levels from which branch ducts distribute the supply to individual room risers in the wall construction.

The duct work is of galvanized iron construction throughout and is generally proportioned for comparatively low velocities of air flow, the various branch duct lines being proportioned for velocities of 1,200 to 1,500 ft. per minute while in the wall riser flues, the velocities are further reduced to from 400 to 500 ft. per minute. The fresh air outlets into the various classrooms which are located 11 ft. above floor level are fitted with deflectors or diffusers for the purpose of distributing the air freely over the ceiling and preventing draft; these diffusers which are, as shown in the accompanying detail, inverted galvanized iron aprons, are of different sizes and forms in the various classrooms to fit the registers and properly distribute the air in the room in each case.



Details of Ventilation on the Upper Floors of High School Building.

The auditorium ventilation scheme differs from that in the remainder of the building in that the best theater and public hall practice is followed, a supply of sufficient fresh air being provided for to give the required 30 cu. ft. of air per minute to every person of the maximum audience of 1,700. The fresh air supplied to the auditorium is warmed enough above 70° Fahr. to give 70° temperature in the room, this being controlled by Johnson system control of steam to the central heating chamber from thermostat placed in the auditorium; the direct radiation in auditorium is only enough to maintain room at about 50° Fahr. in zero weather.

The fresh air supply to the auditorium is delivered through side wall registers near the ceiling line both above and below the gallery at the sides and the rear, of which the registers on the 15th St. side only are furnished by the system for that part of the building, while those at the rear and northerly side of the room have connections to the 16th St. division blower. The supply from the latter blower is as above stated distributed by underground distributing duct connections, the main flue for which is of full size of the fan delivery in order to permit of its operation to maximum capacity upon the auditorium supply alone; there is for this purpose a swing damper installed in the delivery duct connection, which permits the entire supply to be delivered exclusively into either the house or the auditorium systems, or divided between the two, as desired. The supply registers to the auditorium are long, narrow grilled openings arranged above the doors opening into the corridors and are each fitted with diffusing louvres which are set to distribute the air on the ceiling.

The exhaust ventilation of the auditorium is accomplished through registers placed near the floor line both above and below the galleries and surrounding the stage at the rear, which open either into wall flues or passages behind furred wall construction that connects with wall flues. The vent registers at the rear of the stage are of large capacity and connect through the furred spaces at the rear to a single large discharge hood above the roof of the interior court at the second floor level. The vent registers in either side wall of the auditorium connect separately to large riser shafts enclosed in the building construction at points nearby that lead up to discharge hoods above the roof.

The exhaust ventilation of the remainder of the building is also, as above stated, accomplished by natural draft assisted by the plenum caused by the delivery of air from the blowers into the rooms served. Each room had its vent outlet which corresponds in size to that to the inlet register for fresh air supply, located in the sidewall close to the floor level which connects into a wall flue rising to the roof. These wall flues are carried up individually to the roof level from each room and are joined there in groups of from four to eight flues, according to the location and number of rooms served, into a discharge stack carried 2 ft. or more above the roof level with hoods for protection from the weather.

The school building and its entire equipment was designed by the Board of Education of the City of New York, of which Mr. C. B. J. Snyder is Architect and Superintendent of School Buildings. The details of the heating and ventilating and power equipment of the buildings were designed under the direction of Mr. F. G. McCann, Chief of the Heating and Ventilating division. The steam plant and heating and ventilating equipment were installed by Blake & Williams, New York.

Preservation of Steel Reinforcement in Concrete Structures.

It has generally been accepted by architects and engineers that the steel reinforcement in concrete structures was perfectly preserved against corrosion by the cement. This fact is well demonstrated by the conditions found in tearing down a one-story reinforced concrete building erected by the Turner Construction Co., New York, in 1902, for J. B. King & Co., at New Brighton, Staten Island, N. Y.

This building had a pile foundation, the piles being cut off at mean tide level. The footings consisted of reinforced concrete placed around and over the heads of these piles. The walls had a thickness of 9 in. up to the grade line and 5 in. from the grade line to the roof, a height of approximately 15 ft. The roof consisted of reinforced concrete beams and girders, the roof slab having a thickness of 2½ in. reinforced with ¼-in. twisted steel bars spaced 12 in. on centers. The walls were strengthened by pilasters, and both walls and pilasters were reinforced with twisted steel bars. The interior columns had a cross section 11 in. square and were reinforced with four ⅜-in. twisted steel bars held together by ¼-in. hoops of twisted steel spaced 2 ft. 6 in. on centers.

The portion of the building removed had an area of 30 x 60 ft. and was razed to make room for a five-story structure. No headway could be made in wrecking the roof by a hand hammer and point owing to the extreme hardness of the concrete. Sixteen-pound sledges were then used and were found very efficient in knocking holes through the roof slab, and when once a large hole was formed it was an easy matter to continue the wrecking.

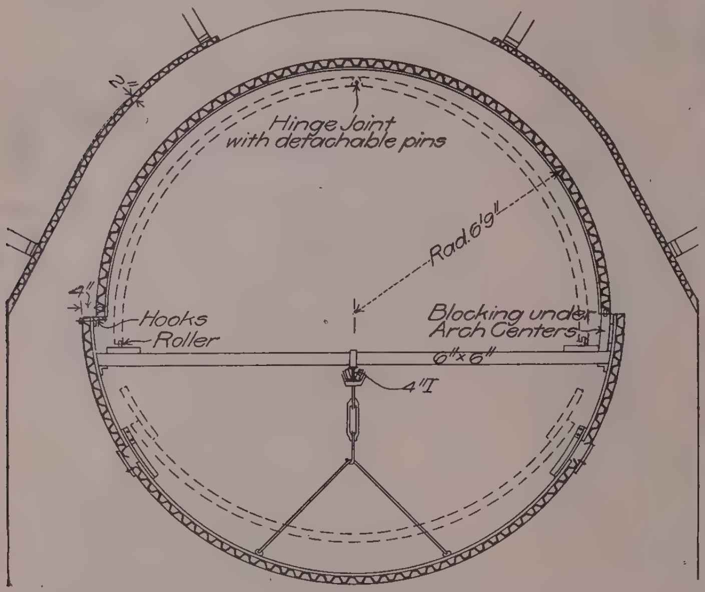
The walls were pulled over by block and fall and showed very clearly the elasticity of the wall. These walls were anchored to the footings by bond bars which had been placed with the footing. Before falling the wall would lean at least 20 deg. from the vertical and remain intact. The columns after being cut free at the top would bend back and forth like a sapling before the vertical bars would break. The bars finally broke at the junction between the footing and the column, permitting the entire column to fall over unbroken.

All steel reinforcement was found in perfect preservation, excepting in a few cases where the hoops were allowed to come closer than ¾ in. to the surface. Some evidence of corrosion was found in such cases, thus demonstrating the necessity of keeping the steel reinforcement at least ¾ in. from the surface. The footings were covered by the tide twice daily. The concrete was extremely hard and showed no weakness whatever from the action of the salt water. The steel bars in the footings were perfectly preserved, even in cases where the concrete protection was only ¾ in. thick.

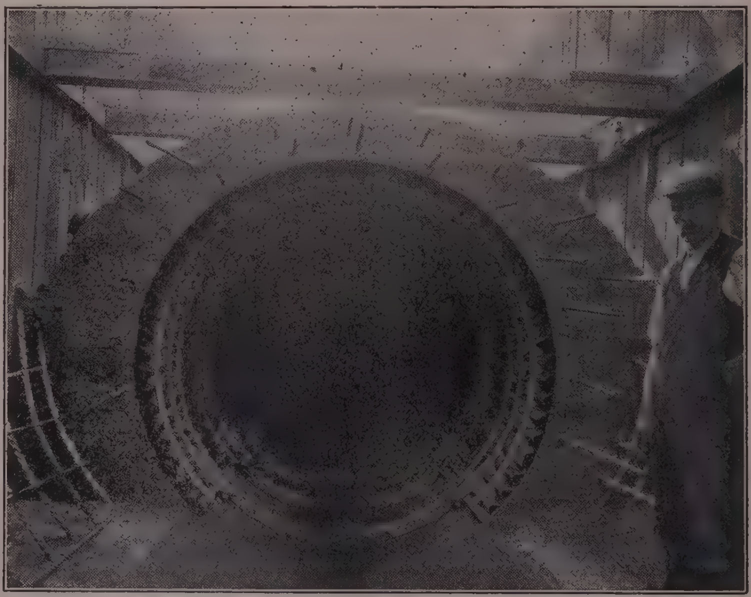
A New Type of Forms for Concrete Work.

During the past year there has been used on a number of sewer contracts in New York City and vicinity a new type of steel centering which possesses certain advantages over other forms of centering used hitherto. These forms while originally developed for use in sewer work are also adaptable to practically all other classes of concrete construction. Each unit or section consists of three light-gauge steel sheets, two of them parallel to the desired surface and having between them a third specially corrugated sheet to which they are securely fastened. A clear idea of this arrangement is given by accompanying illustrations.

The thickness of the form varies according to the requirements of the work on which it is to be used; in general the thickness is from 1½ to 3 in., and the gauge of the sheets runs from No. 24 to No. 16. By this construction the inherent strength of the corrugated plates, acting as a beam in a direction parallel to the length of the corrugations, is increased by the outside plates which act as continuous flanges forming a multiple plate girder. Considered as a beam acting in a direction across the length of the corrugations, each unit is a simple Warren truss, the outside plates being the chords and the corrugations of the inside plates forming the diagonal members. Flat sections of such forms weighing less than 4 lb. per square foot develop about twice the resistance of 2-in. yellow pine planking.



Forms for 13½-Foot Sewer with Brick Invert Lining.



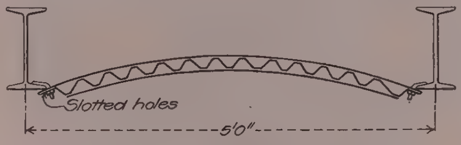
An 8-Foot Sewer Built with Duralite Forms in Brooklyn.

For walls, floor slabs and the like, flat panels of this sort erected against studs in the usual manner have the advantage of reduced weight and the increased strength over 2-in. planking allows the studs to be spaced twice the usual distance apart. For attaching the panels to the studs during erection when this is required, hinged eye-straps have been devised which facilitate the easy erection and dismantling of the forms.

When curved centers are required the usual sheet of metal on the free face of the forms is replaced by narrow steel bands spaced about 24 in. center to center and bolted to the corrugated sheet at every point of contact. The spacing of the bolts in these straps determines the radius of curvature and to vary the radius in any panel, producing compound curvature if desired, it is only necessary to space the bolts to meet the requirements.

Centering for sewers constructed in this manner is self-supporting and does not require any inside bracing or studding. This obviates the necessity of adjusting any moving parts in collapsing and moving forward the centering and leaves almost the entire cross section of the bore clear for the passage of workmen or for the operation of material cars in tunnel work. Moreover, rear sections of centering on which the masonry has taken its set can be collapsed, drawn forward through the sections on which masonry is being laid and set up in advance. This feature effects an economy of 20 to 40 per cent. in the total lineal feet of centering required on continuous work. It also makes possible absolute monolithic construction without vertical or horizontal joints.

Sewer forms of this type are said to be extremely rigid and in using them it has not been found necessary to exercise extreme care to load them symmetrically, though symmetrical loading is, of course, desirable to prevent possible distortion and for other reasons. In general, sewer work constructed with these forms has been handled in 16-ft. sections. Allowing one day for the concreting of each 16-ft. section, 48 lin ft. of centering is required if the concrete is to be given three days set before the centers are struck. If more time is required, more centers must be used. The total amount of open ditch required is considerably less with these forms than with those which are non-telescoping, the amount with this type of centers being only about 50 to 60 ft. Where it is desired to eliminate all joints as on a water supply conduit, it has been suggested that the concrete can be deposited to its own slope, running from the invert of one section to the arch of the next, the work proceeding without interruption.



Centering for a Jack Arch.

Centering for a 13-ft. 6-in. sewer, designed to receive a 4-in. brick invert lining, is shown in an accompanying illustration in which the dotted lines show the positions of the forms during the operations of moving. Another illustration shows the centers used on an 8-ft. sewer with a brick invert lining, built by Messrs. P. J. Murray & Co., Brooklyn, in Dycker Heights, Brooklyn.

This type of concrete form has been given the trade name "Duralite," and it is fully covered in the United States Patent Office. The form and its developments is the invention of Mr. Keith O. Guthrie, Asso. Mem. Am. Soc. C. E. It is manufactured and leased or sold by the Duralite Co., 42 Broadway, New York City.

Tuberculation and the Flow of Water in Pipes.

The various deposits which lessen the carrying capacity of water pipes and conduits may be divided into three classes: 1, Incrustations, commonly known as tuberculation, on unprotected or imperfectly protected iron pipes. 2, Deposits or growths on the inner surface of iron pipes whether protected or unprotected, and of conduits, rock tunnels and other channels; the nature of the deposits depending on the chemical constituents or biology of the water or both. 3, Accumulations of debris and mud in invert hollows and dead ends.

Incrustations are formed in iron pipes by corrosion where the inner surface is not protected or is imperfectly protected. Incrustations begin as minute projections scattered over the surface generally in an irregular manner. In forms they resemble small asymmetrical cones or limpets. They grow by addition in concentric layers. They increase in size and numbers until they ultimately become confluent and form a coating of considerable thickness. A pipe of small diameter is sometimes completely choked by them but in large pipes the thickness of the deposits seems to be limited to about 1½ in., according to Mr. Nicholas S. Hill, Jr., from whose paper presented before the American Water Works Association these notes have been taken.

Examples of the space occupied by rust together with the age of the pipe are given in an accompanying table. This space is ascertained by filling the pipe with water, noting the quantity and deducting it from the capacity of the pipe when cleaned.

Age Years.	Diam., In.	Amt. of Rust per Ft. Cu. In.	Cap. of Clean Pipe per Lin. Ft., Cu. In.	Per Cent. of Space Occupied by Rust.
29	4	60.79	150.33	40
22	4	81.45	150.33	54
14	6	60.00	326.68	18
15	6	63.33	326.68	19
16	10	80.00	941.76	8.4
30	16	440.00	2,419.20	18

Limestone, shale and other rocks from which water dissolves salts of calcium and magnesium, produce waters which contain a large amount of mineral matter. Of these salts the one which is chiefly deposited in water mains is the translucent semi-crystallized scale of calcium carbonate. The character and effect of these deposits is well known. At Bath, England, 2 in. in length of 6-in. pipe contained 26,786 grains of calcium carbonate or at the rate of 23 lb. per lineal foot. Mr. Le Conte states that in San Francisco pipes which have been in use for 10 or 25 years usually show a lime scale on the inner surface, making it somewhat rougher than the new surface of asphalt, but no material change in the value of C has been noted as yet for the larger size pipes.

Probably the most serious biological effect produced in pipes is due to the so-called iron organisms belonging to the Crenothrix groups. In some places this slime is easily disengaged from the pipes and floats away in flocculent masses which seriously impede the service pipes. In others the coating seems to be more permanent and in places in England an annual cleaning with brushes or scrapers is resorted to for its removal. Crenothrix possesses the power to increase very rapidly so that in a few months after the introduction of its germs it covers the pipe walls to quite a thickness. Its development has been in many cases sudden and without warning, causing serious inconvenience and many complaints.

The remedies or palliatives for these various difficulties are classified by Mr. Hill as follows: 1, Rust, tuberculation or rust nodules; perfect or improved pipe coating or cleaning by scraping. 2, Incrustation due to alkalinity; removal of carbonates by treatment with milk of lime or cleaning by scraping. 3, Biological formations; filtration or filtration and removal of iron or scraping. 4, Sedimentary deposits; clarification by sedimentation, filtration or otherwise or flushing and scraping.

The removal of incrustations and deposits in pipes by scraping has not been largely resorted to in this country up to the present time, but in England scrapers for cleaning mains have been in use for 30 years. In some places where the Crenothrix is encountered the mains are scraped annually. The following table shows the percentage of gain in delivery reported at places in Great Britain and Ireland as a result of scraping.

Place.	Size.	Per Cent. Gain.	Place.	Size.	Per Cent. Gain.
Owestry	6 in.	54	Omagh	6 in.	300
Lancaster	8 "	56	Lanark	7 "	34
Bradford	18 "	55	Bridge of Allen	6 "	35
Whitelawn	12 "	28	Thurso	6 "	7
Waterford	13 "	40	Cowdenheath..	6 "	23
Cuper Fife.....	7 "	52	Burntisland ..	8 "	43
Merthyr Tydfil.	14 "	30	Torquay	10 "	28
Merthyr Tydfil.	12 "	82	Aberdeen	4 "	107

At Halifax, St. John, Boston and a few other places in New England, scraping of water mains has been practiced to some extent. The effect of scraping in Halifax, as stated in a paper before the American Society of Civil Engineers by Mr. E. H. Keating, city engineer, in 1882, was very beneficial. The average pressure on 25 hydrants along the water front in February, 1880, 1881 and 1882 was 34.2, 43.5 and 52.4 lb. per square inch, respectively. The pressures taken at the same times at the highest plug in the city were 8, 28 and 34 lb., respectively. The mains were all heavily tuberculated, in some instances the incrustation being 1½ in. thick.

In Boston the pipes cleaned were not the supply mains but the distributing pipes in the streets, the size being 6 in. and 12 in. Mr. Dexter Brackett, who described this work before the New England Water-Works Association, stated that the discharge of 6-in. tuberculated pipes was from 25 to 35 per cent. of the quantity which a clean coated pipe might be expected to deliver on the same head, and that the discharging capacity of the pipes was more than doubled by the removal of the tubercles.

The incrustations and deposits which form in water mains affect not only the potableness of the water supply, but also the earning capacity of the plant. A surprisingly small amount is spent on the maintenance of water distribution systems in this country according to Mr. Hill, who has prepared a short table showing such data for five American cities, ranging in population from 15,000 to 450,000, in all of which the distribution is by pumping. In these cities, with one exception where unusual conditions may have existed, the total cost of maintenance of the pipe is less than 2 per cent. of the total cost of repairs and less than 0.8 per cent. of the gross revenues. The cities were picked at random and according to Mr. Hill, are representative of "American practice" in that a diminution of pressure or capacity in the distribution and supply main is universally met with supplementary extensions.

There are very many instances, Mr. Hill states, where more money spent in maintenance would have saved immediate heavy outlay for new construction which, if paid for from revenues forestalled other needed improvements or dividends, and if paid for by bond issues increased the fixed charges of the plant by an amount greater than the proper maintenance cost.

For example: Suppose a 6-in. main to cost $1 per foot and to require replacing with another main of the same size in 20 years, owing to increased consumption and the effects of tubercular deposits. Assume money to be worth 4 per cent. per annum. Then the cost of a new main at $1 per foot, 20 years hence, would be equivalent to 46 cents at the present time. Assume that by proper inspection and cleaning the construction of the additional main could be delayed 10 years. The cost of a new main 30 years hence would be equivalent to 30 cents at the present time, therefore, $46 - 30 = 16$ cents per foot would thus be saved, which at 4 per cent. $= 0.64$ cents per foot per year. Add to this the saving in interest on $1 per foot for 10 years $= 4$ cents per foot per annum, and we have $(0.64 \times 20) + (4 \times 10) = 52.8$ cents per foot of 6-in. main as the amount we would be justified in spending in maintenance during 30 years, in addition to the present cost of repairs, which is assumed to be the same, and which averages about 17 cents per foot per year for all sizes of mains. In other words, it is justifiable, according to Mr. Hill, to spend ten times as much for maintenance as is spent at present even if all the pipes were only 6-in. If the periods are reduced to 10 and 20 years respectively, which is more probable with heavy incrustations, then the justifiable expenditure for maintenance would be 48.4 cents per foot for 20 years and 2.42 cents per foot per annum, which would be sufficient to clean the mains once every five years. This estimate refers to the distribution system. Supply mains and force mains from pumping stations would justify a much larger outlay even if the pipe were only of the same size. This estimate, of course, takes no account of the many other advantages derived, nor of the saving to the plant by an amount greater than the proper maintenance costs.

A FREIGHT HANDLING CONVEYOR for the transfer of package freight from steamship docks to warehouses, some 250 ft. distant, has recently been installed in Seattle, Wash. The carrier is of the Jeffrey apron or wooden flight type, and is supported by a light timber elevated structure above a much-traveled street and railroad tracks. The carrier is 36 in. in width, and made up of flights 9 in. wide, 4 in. thick and 30 in. in length, pivoted at 12-in. spacings to two strands of steel thimble roller chains. Wedge-shaped blocks are secured to every third flight to hold freight that might not ride securely on the flat apron. The conveyor is driven by a 10-h.-p. electric reversible motor permitting the handling of freight in either direction, and is operated at 70 ft. per minute.

Garbage Disposal in Milwaukee.

In The Engineering Record of Jan. 4 attention was called to a report on the disposal of garbage and other refuse in Milwaukee, which was recently made by Dr. Rudolph Hering. The report gave an analysis of the cost of disposing of various classes of city refuse by different means, and it is proposed in this article to give more detailed information concerning these estimates than was desirable in the previous editorial mention of the report. While Dr. Hering was retained by the city primarily to investigate methods of disposing of garbage, it soon became apparent in the course of his studies that it was essential to consider other waste materials. The reasons for this were two-fold: First, because the expense of disposing of the garbage may be materially affected by the manner in which other refuse is finally disposed of; second, because, from a sanitary point of view, the proper disposal of rubbish is probably of even greater importance than the disposal of garbage.

Practically all methods of garbage disposal have been tried in Milwaukee and all have been found wanting in one way or another, not due to the method itself, but rather because the works were either improperly designed or the operation of disposal was inefficient or conducted mainly for profit. The garbage is now being burned in a crematory so located that the expense of taking the garbage to it and of burning the material there is probably 45 per cent. more than the cost of conducting similar operations in a more suitable location which is available for the purpose. Moreover the present incinerator has insufficient capacity to handle the garbage adequately and economically during the summer months, when the largest amount of this class of refuse is produced, and its improper disposal causes the greatest nuisance. The other classes of municipal refuse have apparently received little attention. There appears to be little agitation as yet to change the method of disposing of rubbish by dumping, although from a strictly health point of view, Dr. Hering considers it the more serious nuisance. There is little objection to the present methods of dumping ashes and street sweepings. Any change likely to be advocated would be wholly in the direction of economy in the disposal, but there is some indication that the disposal of stable manure is likely to demand serious consideration at an early date.

The amount of garbage collected in Milwaukee during 1906 was 38,550 tons, the amount per month ranging from 2,368 tons in February to 4,427 tons in August. Analyses made by Prof. R. E. W. Summer, of Milwaukee, show that in 100 lb. of dry garbage there are 61.88 lb. of ashes, 38.12 lb. of combustible matter, 8.775 lb. of grease, 1.61 lb. of nitrogen, 12.5 lb. of glucose, and 2.31 lb. of phosphoric acid. One pound of dry garbage gave 4,522 B. t. u. on combustion. In 100 lb. of wet garbage there were 22 lb. of dry garbage and 78 lb. of water. In 100 lb. of wet garbage there were 13.61 lb. of ashes, 8.39 lb. of combustible matter, 1.93 lb. of grease, 0.35 lb. of nitrogen, 2.75 lb. of glucose and 0.51 lb. of phosphoric acid. When the garbage was piled to height of 24 in., about 9 1/3 per cent. of the water contained in it drained off. If 100 lb. of wet garbage are piled up in this manner and that amount of water allowed to drain off, there will remain about 68⅔ lb. of water which must be evaporated, calling for 66,371 B. t. u. Adding the heat required to raise the temperature of the garbage to the boiling point, it is found that 82,173 B. t. u. are required theoretically to evaporate all the water in 100 lb. of wet garbage after it has been piled to a height of 24 in., and allowed to drain. As 1 lb. of dry garbage gives 4,522 B. t. u., the 22 lb. of dry garbage that are contained in 100 lb. of wet garbage should generate 99,484 B. t. u., and Prof. Summer therefore concludes that theoretically the wet garbage, after the free moisture has been removed by its own pressure, should burn itself without the addition of coal. Dr. Hering states that these conclusions and experience elsewhere indicate that under proper management and in proper furnaces there should be no difficulty in burning the Milwaukee garbage alone without fuel during much of the year. He also believes that the analysis shows there is barely enough grease in the Milwaukee garbage to make a reduction system of disposal profitable.

If the garbage of the city is disposed of by reduction, Dr. Hering states that the works must be so located that no nuisances are caused, and it has been found that the most satisfactory way to secure this condition is to place the plant outside of the city. The best method of final disposal of the other classes of objectionable refuse is burning. Incineration can be so conducted that no offense is created and the works may therefore be located within the city. On this account one method of disposal will be to reduce the garbage outside the city limits and incinerate the other refuse within them. If the garbage and other refuse are both burned, then a joint crematory for all classes of refuse becomes feasible and can be located within the city limits, for with careful management there is no reason to expect a nuisance. The best place for a reduction plant is stated to be Mequon, 13 miles from the harbor and near both a railroad and the lake. The best site for a crematory is on property in the city already belonging to the municipality. Dr. Hering emphasizes the fact that in any comparison of the two projects it is essential that the collection of the refuse be considered in order that the relative economies of the two methods may be definitely ascertained.

To deliver the garbage to the reduction works at Mequon means a collection of this material by wagons from the households for delivery to points where it can be transferred to cars or boats, and finally its shipment by rail or water to Mequon. It appears that there is no better place of transfer from wagons to cars or boats than the proposed site for a crematory. Consequently, it is assumed that all of the city's refuse requiring treatment must be delivered to that point, and the kind of treatment will not affect the cost of collection to this site. If the garbage alone must then be taken to Mequon, it is necessary to add to the cost of this method of disposal the further expense of carrying it there, as it will be necessary to reload it and transport it by rail or water. Water transportation will be cheaper, but the delays due to stormy weather and ice will interfere with it, and as a proper system of collection should not be subject to such interference Dr. Hering does not believe that water transportation should be seriously considered as the only method of delivery. None of the railroads would quote rates for hauling garbage to Mequon, apparently because it is not to their interest to engage in such business. It seems evident that a special train service for the work will be necessary. Owing to the difficulties in Milwaukee on account of limited space for sidings, reloading and uphill gradients, Dr. Hering estimates that it will cost 70 cents per ton of garbage to take that material to the reduction works and return the empty boxes.

If coal is worth $3.75 per ton, then as the amount of coal in domestic ashes may be safely taken as 20 per cent. of the whole, according to Dr. Hering, the fuel value of a ton of ashes in an incinerator kept at a temperature of at least 1,200° Fahr., when all coal would be consumed, is 75 cents. If the expense of hauling ashes is 25 cents per ton-mile, it will therefore pay to haul them 3 miles. If it is further considered that they must in any event be hauled on an average of about 2 miles to a suitable dump, and that the average haul from the built-up part of the city to the proposed site of the incinerator is not over 2 miles, it is concluded that the fuel value of ashes will justify a 2-mile haul. On the other hand, there is a value in ashes for filling purposes, but this is maintained after their complete incineration. A similar course of reasoning is followed to show that a ton of rubbish also has a value of about 75 cents. Whatever method of disposal is adopted, Dr. Hering believes the garbage should be collected separately from the other classes of refuse.

The average cost of delivering garbage and dead animals to the site of the proposed crematory was $1.54 per ton during 1906 and the cost of delivering ashes and rubbish to the various dumps was $1.31 per ton.

In estimating the net cost of the reduction process, Dr. Hering states that he does not believe it is safe to assume that the grease made by this process can be sold at an average figure of more than 4 cents a pound, nor the dry fertilizer filler at more than $5.00 a ton. On the basis of these figures Dr. Hering states that a permanent profit of perhaps $12,000 per annum may be expected from 116 tons of garbage per working day and a profit of $15,517 per annum for 150 tons daily. As the daily quantity of garbage sometimes has reached 200 tons per day, the initial investment for a reduction plant is estimated at a minimum of $225,000. The successful operation of a reduction plant means the conduct of a fairly intricate manufacturing business, something that is rather unusual in city administration in the United States.

If the reduction process is adopted it is necessary to provide furnaces for burning the other classes of refuse. An incinerator for 100 tons daily capacity will cost about $75,000, according to Dr. Hering, who estimates that this amount of rubbish should produce 200 kilowatt-hours, provided the heat from burning the rubbish is utilized in a power plant. Such a power plant will cost about $14,000. This electricity can be sold at at least 1 cent per kilowatt-hour, according to the report. The clean ashes from the crematory are estimated to be worth 25 cents a ton for filling material and other purposes. A plant of this sort will require an initial expenditure of $89,000. Estimating interest and depreciation at 10 per cent., the cost of incinerating 100 tons of refuse at $45.00, and the expenses of operating the power plant at $14.52, there is a total daily expense of $88.23. The profit is figured at $48.00 for 200 kw.-hr. of electric current, $2.50 for 10 tons of ashes, making a total of $50.50 per day. The net cost of incineration is thus $37.73 per day, or 38 cents per ton. The total cost of disposal of all classes of refuse under consideration, if the reduction process for garbage is employed, is made up of the following items: Daily delivery of garbage to Mequon, 150 tons at 70 cents per ton, $105; daily incineration of rubbish, 100 tons at 37.73 cents, $37.73; total cost, $142.73. Total revenue, $50.00. Net cost per day, $92.73; net cost per ton, 37 cents.

The second method of disposing of the refuse of the city, the incineration of all classes of it, will only be successful in crematories in which a high temperature, averaging 1,500° Fahr., is maintained steadily. By keeping up this temperature two important objects are gained: 1, the great heat destroys all organic matter in the garbage and all sources of odor, for no partially burned solids or gases are left in the furnace; 2, the great heat, being continuously maintained, affords an opportunity for carrying on a power plant. From the examinations that have been made, Dr. Hering believes that it is possible to count on a pound of steam per pound of refuse during the fruit season, when the degree of moisture in the refuse is greatest, and 1¼ lb. of steam per pound of refuse in the winter, when the coal in the ashes is greatest. He states that a plant capable of disposing of all the garbage, most of the rubbish and ashes, and some of the manure, should have a capacity of 450 tons per day and be operated 24 hr. per day. It should be so arranged that the heat production is most economically achieved, that the garbage may be relieved of its surplus moisture before it is thrown upon the fire, and that the minimum temperature does not drop below 1,200° Fahr. The furnace should have forced draft and the air should be taken from within the building, to prevent the escape of dust and smoke from the outside. There must be storage room to enable the refuse to be fed, of such kinds or quantities, as may be required at any time. A crematory and power plant together with the necessary buildings and ground, of this character and of such a capacity, is estimated to cost $307,000. The daily cost is itemized as follows: Operation, 450 tons at 35 cents, $157.50; cleaning and repairs at 5 cents, $22.50; engineer, assistant and electrician, $20.00; interest and depreciation, 10 per cent. for 310 days, $99.03; total, $299.03. The revenue from such works is itemized thus: 1,000 kw.-hr. at 1 cent, $240.00; 50 tons of clinker at 25 cents, $12.50; total revenue, $252.50. Net cost per day, $46.53 or 10 cents per ton.

The statement in the report referring to the sale of electric current is as follows: "The estimate of 1,000 kw.-hr. is conservative, if the electricity can be disposed of continuously for power or lighting, to do which should not offer great difficulties in this city. When it is realized that refuse such as Milwaukee rejects has a calorific value in its garbage, rubbish and ashes sufficient to maintain in a furnace an average temperature exceeding 1,200°, without the continuous addition of coal, it cannot be questioned that the value of such heat should be utilized for the purpose of reducing the cost of such refuse disposal."

In case it is not deemed financially desirable at present to build an incinerating plant for 450 tons of refuse daily, it will be practicable to build a plant for incinerating chiefly the most objectionable refuse, the garbage, rubbish and some manure, which plant should have a capacity of 300 tons daily. It will cost, according to Dr. Hering's figures, $124,000 for furnaces and their appurtenances, $43,000 for buildings and grounds, and $33,000 for power plant, making a total of $200,000. The cost per day will figure out at $135.00 for burning 300 tons, $15.00 for cleaning and repairs, $15.00 for the wages of the engineers and electricians, and $64.51 for interest and depreciation, making a total of $229.51. The revenue from such a plant is estimated as follows: 600 kw.-hr. at 1 cent, $144.00; 26 tons of ashes at 25 cents, $6.50; total, $150.50. Net cost per day, $79.01; net cost per ton, 26 cents. The reason that the net cost per day is greater with the smaller plant is that the operating cost is higher because it may be necessary, in the absence of domestic ashes, to add some coal at times to maintain the required high temperature. By gradually increasing the number of furnaces and adding domestic ashes, the net cost per day will be correspondingly reduced as the sale of power increases. The cost of incinerating garbage alone at Milwaukee in 1906 was $1.30 per ton. This very high cost, in comparison with the estimates made by Dr. Hering, is explained by him on the ground of the use in the present crematory of a large quantity of coal, unnecessary in modern incinerators, and the waste of a large amount of heat without utilization. His recommendation to the city is to construct a plant of 300 tons daily capacity, costing $200,000, and to make provision for extensions from time to time as they may be needed.

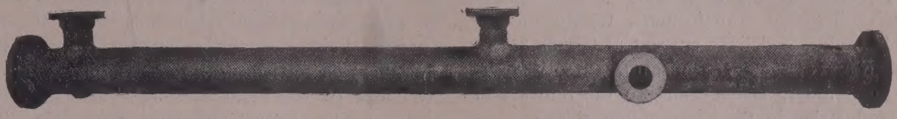
Some Unusual Welded Steel Pipe Work.

While German and English practice in the welding of wrought iron and steel pipe was formerly slightly in advance of that in this country, the present state of the art here has become very highly developed, some notable pipe and flange welding having been accomplished recently in both intricate forms and large sizes of pipes. The earlier advance abroad is due in all probability to the more extensive adoption of the use of superheated steam in power plant operation, which made it desirable to avoid joints in piping systems owing to the consequent large reduction in maintenance charges. This led to the introduction of open-hearth steel pipes with welded flanges and outlets for power plant piping systems, which form of construction has been used abroad for nearly twenty years. With the increasing use of superheated steam in the United States during the past few years and as the advantages of this practice became more generally known, the art of pipe welding has become highly developed and work of this character rivaling or even excelling that abroad is now to be had in this country. Such work in both wrought iron and steel is done in a great variety of forms and sizes by the M. W. Kellogg Co., of New York, which has a large factory in Jersey City, specially fitted for this purpose. The accompanying illustrations of some difficult pieces of work in both large diameters and great lengths of pipes, which have been manufactured by this company, indicate the extent to which this class of work has been carried.

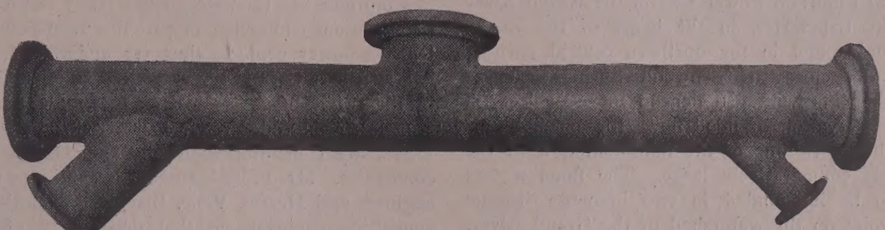
The experience of the company indicates the feasibility of forging wrought steel pipes and welding them into nearly any form, shape or size. Flanges are welded on the sides of pipes with great facility, rendering the construction of headers or receivers for power plant piping, capable of withstanding the maximum pressures and temperatures, entirely practicable and also very desirable, for such headers are entirely free from joints and the leakage of riveted built-up construction. The accompanying illustration of a 30-in. receiver header with four horizontal supply connections and nine vertical delivery outlet nozzles shows a very desirable application for this class of work for high pressure piping. It has also become desirable, for the purpose of eliminating joints, to make each single piece of pipe as long as possible, the only limits of length being, in fact, the physical conditions affecting the shipping of the finished work from the factory and the clearances or obstructions at the place of installation which might interfere with its erection. The accompanying illustration of a piece of 12-in. steel pipe 34 ft. in total length, with three flanged outlets 5, 6 and 8 in. in diameter, indicates what has been done in this direction. An illustration is also given of another difficult piece of work consisting of an 18-in. steel pipe, 19 ft. long, with a 20-in. side outlet and two 14-in. 45-deg. outlets near the entrance on the opposite side.

The welding on of flanged nozzles for all outlets is particularly desirable in that all welding work can be done first and then the machining or finishing work done later, with consequent elimination of the liability to errors in the correct lining up of faces and drillholes. This facilitates the manufacture and completion of work, including the drilling of flanges, with the surety that it may be erected without difficulty at the point of installation. This welding of nozzles and outlets on the sides of pipes has been made successful by the Kellogg Co., by the reinforcement of the metal in the side of the pipe at the point of weld, it being their customary practice to make the metal at these points approximately two and one-half times the original thickness of the pipe wall before welding; that is, if the wall of a 12-in. pipe is ⅜ in. thick, it is reinforced for a distance of about 2 in. radially around the section where the nozzle is to be welded on to a thickness of from ⅞ to 1 in., and in the welding this extra thickness is retained as a fillet from which the thickness tapers away gradually on either side into the original thickness of the pipe used. This reinforcement is effective in greatly strengthening the joints, rendering it much stronger at the points of the welds than the normal section of the pipe itself.

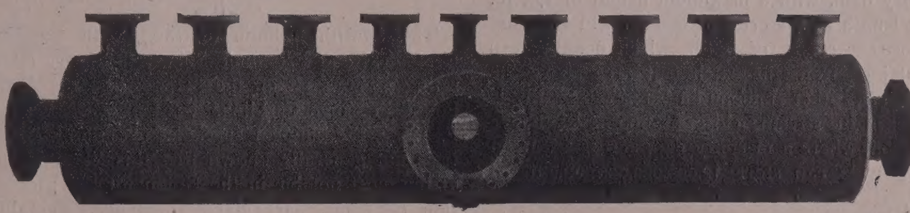
The advantages claimed for the use of this pipe construction for power plant work are stated as follows by the makers: 1, The great saving in weight on account of the use of wrought open hearth steel instead of heavy castings. 2, The saving in labor of erection on account of the decrease in weight and also a decrease in the number of joints to be made up, of from 50 to 70 per cent. according to the piping layout. 3, The decrease in the cost of insulation covering, due to the fact that the work of covering long straight runs of pipe, unbroken by flanges, is much more easily and quickly done than where the runs are broken up with flanges and fittings. If superheated steam is to be used, another important advantage is claimed in the ability of open hearth steel to withstand the high temperatures and variations of temperature with comparatively little loss of strength. Steel of the grade used for this class of piping is stated to lose but 1.1 per cent. of its strength when raised to a temperature of 575° Fahr. and only 8 per cent of its strength when raised to a temperature of 750°, whereas it is well known that cast-iron loses strength rapidly when subjected to temperatures above 375° Fahr. It should also be stated that the company is making some remarkable bends in large pipe, and has recently bent a heavy 12-in. pipe to a radius of 15 in.



Twelve-Inch Pipe Thirty-four Feet Long.



Eighteen-Inch Pipe Nineteen Feet Long.



Thirty-Inch Receiver Header with Four Inlets and Nine Outlets.

A SYSTEM OF BLOCK SIGNALS has been completed by the Baltimore & Ohio R. R., covering all tracks on its new 4-track system between Pittsburg and McKeesport, Pa., the work having been begun about three months ago and costing $150,000.

Large Hydro-Electric Projects in Colorado.

Allied interests represented by The Central Colorado Power Co. and The Eastern Colorado Power Co. have under construction and in contemplation in Colorado a series of hydro-electric developments of considerable magnitude. The former company operates on the western and the latter on the eastern slope of the Rocky Mountains in that state. The first of the developments on which construction has been started by The Eastern Colorado Power Co. is in the canyon of Boulder Creek on the eastern slope of the main range of the Rocky Mountains, 4 miles from the city of Boulder and 25 miles from Denver. The hydraulic features of this development are extensive, as the water from which power will be developed must be obtained to a large extent by the conservation of the flood flows occurring during the early summer, which floods are due to the melting of the snows on the mountains in the watershed of the stream. Some of the mountains, however, within the watershed of the Middle Boulder Creek, on which two large storage reservoirs are to be built, are covered with nearly perennial snow, thus producing a comparatively uniform flow, the average annual rainfall in the region tributary to the reservoirs being about 27 in.

The first of the two storage reservoirs is 16 miles above the power station, and will have an impounding capacity of 503,000,000 cu. ft. of water. This reservoir site is being developed by the construction of an earthen dam with a concrete core wall. This dam will have a maximum height of 155 ft. and a length of 800 ft. at the crest. A 36-in. concrete pipe line, with a carrying capacity of 56 cu. ft. per second, is being laid to convey the water from this reservoir to a reservoir with a storage capacity of 12,000,000 cu. ft., which is located on a hill 1,825 ft. above the power station and 2 miles from the latter. This reservoir can be developed by three small earthen embankments, with a maximum height of 35 ft. It will provide water for fluctuations in demand due to the peak loads on the station. A steel pressure pipe will convey the water from this regulating reservoir to the power station.

The second large storage reservoir of this project is on the Middle Boulder Creek at a point 3 miles above the lower one. It will be developed by an earthen dam with a maximum height of 70 ft. and a total length at the crest of 400 ft. This dam will impound 200,000,000 cu. ft. of water, which will be delivered from it into the channel of the stream and recovered into the lower main reservoir.

The 2-mile steel pressure pipe extending from the regulating reservoir to the power station will deliver water to the latter under a static head of 1,825 ft. The station will contain three 6,850-h.-p. I. P. Morris impulse tangential water wheels operating under this high head. Each of these wheels will be direct-connected to a 5,000-kw. 2,300-volt, 60-cycle, three-phase alternating-current General Electric generator of the engine type. These generators are designed so a peak load of 20,000 electrical horse power can be carried by the station. The 2,300-volt current delivered by the generators will be passed through oil-cooled transformers, tapped on the secondary side to deliver current at 66,000, 75,000 or 100,000 volts. Transmission lines will be built to Boulder, Denver and to the mines and other industries in the surrounding country.

The principal other developments controlled by the allied interests are being made by the Central Colorado Power Co. on the Grand River and its tributaries, in the heart of the Rocky Mountains and in the northern central part of Colorado, close to Glenwood Springs. These developments will also depend more or less on the conservation of flood flows for a supply, although the volume of the minimum flow of the river is comparatively large. The flood waters are to be impounded in two immense storage reservoirs on the watershed of the Grand River. The site of one of these reservoirs is in the canyon of the Williams Fork of the Grand River, about 70 miles above Glenwood. At this site a masonry dam, with a maximum height of 175 ft., and a length at the crest of 600 ft., will impound 4,000,000,000 cu. ft. of water, which quantity can be obtained from the catchment area above the dam. The other impounding reservoir site is on the main stream, close to 100 miles above Glenwood, where a masonry dam across a canyon 300 ft. wide can store 12,000,000,000 cu. ft. of water, if carried to a height of 175 ft., thus making the site one of the most remarkable in this country. These two impounding reservoirs, together with the flow of the river aside from flood waters, will render available for diversion from the river for power purposes a low flow of 1,250 cu. ft. per second.

The first power station to utilize the flow thus made available will be about 10 miles above Glenwood Springs. A tunnel, 2.5 miles long and with a water-carrying section of 15.6 x 10.5 ft., is under construction through a mountain, along the base of which the river flows, to deliver water to this station. The water will be diverted into this tunnel by a dam across the river, and will be discharged at the downstream end of the tunnel at a point 170 ft. above the power station. A steel pressure pipe will convey water to the station from the end of the tunnel, and the water will be discharged back into the river again from the latter. The station building will contain two 8,400-h.-p. I. P. Morris reaction water turbines, operating under a static head of 170 ft. Each of these turbines will be direct-connected to a 4,000-kw. 2,300-volt 60-cycle three-phase alternating-current General Electric generator, designed for a 50 per cent. overload.

This station is being built to deliver immediate service, as it is contemplated to extend the tunnel about 8 miles to a point below Glenwood Springs. A total head of 450 ft. can thus be obtained at the lower end of this tunnel, which, with the quantity of water available will enable 45,000 electrical horse power to be developed even during low flows.

A third station also included in the Grand River project will be built in Gore Canyon, about 50 miles above Glenwood Springs, where the water conserved by both impounding reservoirs can be utilized. This Gore Canyon development will embrace a diversion tunnel of the same cross section as the one at Glenwood Springs and approximately 4 miles in length. This tunnel will render available a head of 350 ft. and by means of it 35,000 electrical horse power can be developed.

The various Grand River developments are within easy transmission distance of the rich and extensive mineral deposits in the vicinity of Leadville and Aspen. These deposits have already produced a great volume of mineral wealth, but owing to excessive cost of steam power in the isolated region in which they are located, none but high-grade ores can be worked. The immediate market for power is therefore large. At the same time, transmission lines across the continental divide to supply current to the cities and the rich agricultural region along the eastern slope of the mountains are included in the plans of The Central Colorado Power Co. The two companies also have several other large hydro-electric developments under contemplation in Colorado, the ultimate plans already in process of execution embracing one of the most comprehensive power projects thus far undertaken.

Mr. Albert Carr is the chief hydraulic engineer of the two companies; Mr. F. C. Finkle of Los Angeles, Cal., and Mr. H. T. Herrick of Boston, Mass., are consulting hydraulic engineers to the companies. Mr. P. T. Hanscom is chief electrical engineer and Messrs. Viele, Blackwell & Buck are consulting engineers to that department of the organization.

Book Notes.

The twelfth bulletin of the North Carolina Geological and Economic Survey is a very interesting monograph on the "History of the Gems Found in North Carolina," written by Dr. George F. Kunz, the eminent specialist of Tiffany & Co. It is not generally known that this State is one of the most notable in the Union for the production of gems, particularly diamonds, emeralds, rubies, aquamarines, beryls, hiddenite, rhodolite, amethysts, and remarkable rock crystals. These gems have been found mainly in the course of mining operations, although a few systematic searches for them have been made and two companies are now engaged exclusively in such work. The monograph is profusely illustrated, a number of the illustrations being unusually good examples of color printing, while the text has all the charm that is expected in the writings of the author. The bulletin is to be obtained from Dr. Joseph Hyde Pratt, State Geologist, Chapel Hill, N. C.

Railway engineers will be glad to know that the "Manual of Recommended Practice for Railway Engineering and Maintenance of Way" has been revised so as to include everything in the way of definitions, specifications and principles of practice adopted up to the present time by the American Railway Engineering and Maintenance of Way Association. These standards relate to roadway, ballasting, ties, rails, track, buildings, wooden bridges and trestles, masonry, signs, fences, crossings, cattle guards, signalling and interlocking, records, reports and accounts, rules for the government of maintenance of way forces, water service, yards and terminals, iron and steel structures, and classification of track. On some of these subjects the standards adopted to date do not include very much, while on other subjects they are comprehensive. The book is of the highest value as indicating what engineers from all sections of the country have agreed to consider standard for the time being. While most roads do not use more than a few of these standards, there is an undeniable tendency toward their more general adoption in substance, generally with additions fitting the standards for the special requirements of each individual road. (Chicago, American Railway Engineering and Maintenance of Way Association, 962 Monadnock Block; $3.00.)

Deep mining has not yet proved necessary to the extent it is employed in Europe, and for this reason American engineers have to look abroad for most of their information concerning what has been done in reaching deposits overlaid by unstable water-bearing strata. A useful summary of important works of this sort is given in Mr. J. Riemer's "Shaft-Sinking under Difficult Conditions," translated by Messrs. C. R. Corning and Robert Peele. Papers on the same subject written by the author a few years ago attracted such general interest that he has prepared this comprehensive book. Four methods are described, sinking by hand, sinking by the trepan or boring method, the freezing process, and drop shafts. As the book is restricted solely to difficult work, the author has wisely explained under each method the steps taken, both unsuccessfully and successfully, in applying them in actual cases. A great deal can be learned from unsuccessful attempts to conduct such troublesome operations by various plans, and the record of them in this book is unusually instructive. The book is well illustrated. (New York, John Wiley & Sons, $3.00.)

The receipt of a 3½-lb. book on "Economics of Railway Operation," by Mr. M. L. Byers, was a considerable surprise, first because an engineer so busy as the author, who is head of the maintenance of way work on the Missouri Pacific Ry., could find time for such a tremendous amount of writing, and in the second place because it is unusual for an engineer to write as one having authority on operating topics. An examination of the bulky volume shows, however, that the work of the author has been largely that of compilation and condensation; this is likely to give good results when well done and hopelessly poor results when carelessly or uncritically done. Just what opinion the reader will form of Mr. Byers' work will depend on the information he desires, for some places are marked by extreme condensation and others by the full quotation of standard instructions, blank forms and the like. Speaking generally, the book outlines briefly the main features of different aspects of operating topics, shows their inter-relation, and goes into considerable detail in explaining how the work done under each of these features is controlled by instructions and reports submitted to the higher railway officers. As a result of this method of handling the subject, the author has produced an encyclopaedia rather than a condensed manual for the general reader; it will be found a good book for the student of railway affairs, but too detailed for those who have but little time for reading. It takes up in turn the system of organization of a railway company, particularly that of the Pennsylvania R. R., the employment and management of men, accounts and accounting, reports, maintenance of way and structures, machinery department operation, the management of transportation, the conduct of a freight department, the conduct of other departments, the analysis of operations and the control of expenses, and the nature and value of different classes of betterments. In many places the author goes into considerable detail on subjects on which a decided difference of opinion exists, as in the matter of the organization of a railway by departments or divisions, and it is natural that on such subjects those who hold very decided views will not be inclined to agree with all that is said. In the preface the author states that his object has been to bring into view the general outline of the mechanism of railway operation as it is carried on to-day and to develop the principles which have governed in producing the form the mechanism has assumed and those which underlie its economic use, and he has succeeded in doing this in a most creditable manner. (New York, Engineering News Publishing Co., $5.00.)

A useful contribution to experimental results relating to the strength of reinforced concrete beams has just been written by Mr. E. Probst under the title, "Einfluss der Armatur und der Risse im Beton auf die Tragsicherheit." It reports a series of experiments on the tensile and compressive strength of plain concrete and on the bending of plain and reinforced concrete beams. The work was done with the thoroughness characteristic of German technical research and the tests deserve a far more detailed study than the limits of this review of the book permit. The results indicating the location of the neutral axis in beams are specially valuable because they were obtained with three measuring devices operating simultaneously. A formula for the deflection of reinforced concrete beams is deduced and its results are compared with those of the experiments. Perhaps the most valuable results reported are those relating to the accelerated rusting of beams which had been loaded until cracks appeared and the stress in the reinforcement approximated its elastic limit according to the computations. The results were negative for the most part, tending to show that there is little danger of rusting in the vicinity of small cracks, at least for a short period. Another interesting chapter compares the customary methods of computing the strength of reinforced concrete beams that have been adopted in Germany, Switzerland, France and America. There are numerous references throughout the book to the research work done in all these countries and the results and conclusions of Bach, Moersch and other investigators are recorded along with those of the author. (Berlin, Julius Springer; 15 marks.)

The article on hydromechanics which Prof. Wm. Cawthorne Unwin contributed to the "Encyclopaedia Britannica" a good many years ago has long been one of the standard monographs on this complex subject, and consequently the appearance of a "Treatise on Hydraulics" by the same author is an event in technical publishing circles. His long experience as a teacher of hydraulics, his extensive professional connection with the design of hydraulic machinery and hydraulic engineering undertakings, and the eminent clearness of his writings arouse the expectations of the reader. The book will answer the expectations of all but the most critical, for the mistakes in it are very few and refer mainly to experimental results with which American readers are apparently more familiar than the author. The introduction is a statement of the units of measurement employed in hydraulic work and concludes with this significant advice: "Hydraulic problems are most conveniently solved by the use of tables of four-figure logarithms and anti-logarithms. Most hydraulic formulae are affected by empirical constants which are accurate only to one per cent. or at most, in some cases, one per thousand. Hence, in the answers it is unnecessary and useless to keep more than three, or at most four, significant figures." Mention is made of this advice as evidence of the author's belief that until a subject is known well enough to be used in solving problems it is of little use, and the student will find the book particularly valuable on account of the many problems it contains, employed by the author in his classes for many years. The first chapter is a concise statement of the properties of fluids and the second is a similarly condensed explanation of the distribution of pressure in a liquid varying with the level. The third and fourth chapters are on the principles of hydraulics and the discharge from orifices, and the fifth chapter takes up the discharge from notches and weirs; in all these chapters the famous encyclopaedia monograph has been followed to some extent, although data obtained since it was written have been added and there is condensation and rearrangement everywhere. The statics and dynamics of compressible fluids and theoretical and experimental studies of fluid friction are taken up in the next two chapters. The eighth chapter, on flow in pipes, gives an outline of work done by Osborne Reynolds, Coker and others and then discusses various formulas for practical use and experimental data bearing on the subject. In this chapter the American engineer will be sorry to notice that the results of pipe flow measurements made at Detroit are evidently not understood. The results of the Detroit gaugings are among the most important American contributions to the data of pipe flow, particularly the flow in curved pipes, and the inadequate references to them should not be overlooked by the reader. Chapter 9 is an excellent outline of the methods of distributing water by pipes and the problems that arise in connection with such work. The tenth chapter is a review of later investigations of flow in pipes than those described in the eighth chapter, and here again the author does injustice to some of the most important research work done in the United States by omitting all reference to the elaborate and highly instructive experiments made by Messrs. Saph and Shoder in the hydraulic laboratory of Cornell University. A large amount of experimental data are reviewed, however, and from them the author deduces a formula almost identical with those of Messrs. Saph and Shoder and Messrs. Hazen and Williams. The Kutter formula is severely criticized. The chapter closes with sections on the distribution of velocity in the cross-section of a pipe and on the influence of temperature on pipe resistances, which ignore the important American investigations made in these subjects. In the eleventh chapter the flow of compressible fluids such as air and gas is discussed and the results of experiments which furnish data for computations by means of formulas are reported, but evidently the measurements recently made in gas mains have not been brought to the author's attention. A considerable amount of data of this sort has been obtained since the high-pressure system of gas distribution came into use, and while many of the tests have been crude, some of them have been carefully conducted and furnish valuable information. The twelfth chapter is on uniform flow of water in canals and conduits, and here again the author points out the needless complications of the Kutter formula; this chapter contains a review of the more important experimental investigations of the subject and an outline of Prof. James Thomson's theory of stream flow at river bends. The two remaining chapters relate to stream gauging and the impact and reaction of fluids. The book is such a valuable one in its clearness of statement, balance and general accuracy that it is unfortunate it does not contain references to the valuable research work by American investigators of which mention has been made. Both as a class text-book and as a work of reference it will be found of much value, particularly because it approaches many of the subjects it covers in a manner distinctly different from that adopted in other standard works, thus broadening the viewpoint of the student. (New York, Macmillan Co., $4.25.)

Letters to the Editor.

EFFECT OF DRYNESS ON CONCRETE MIXTURES.

SIR: I take the liberty of sending you a few lines concerning a case of difficulty with concrete that may be of interest to engineers and contractors. Some time ago a piece of concrete work was being constructed which gave trouble because, after the forms were removed, the cement was found to be unset. The concrete could be easily broken into pieces and the cement was dead. The stone could be picked out of the mortar and much of the wall fell down. Although I was not regularly testing the cement I was asked to examine it. It proved sound and good, as were the sand and limestone, so I made up a block of concrete from the same sand, cement and stone taken directly from the work. I left this block in the laboratory for 24 hours and was naturally surprised to find that it could be broken up with the hands. The cement was dead and did not adhere to the stone. Not having any stone handy at the time, I picked out the pieces that were used in making this block and used them with some more of the cement and sand in making up another block. This was allowed to stand 24 hours, when it was found to be hard and satisfactory in every way. I became convinced from this that the cause of the trouble was the unusual dryness of the sand and limestone, which had been exposed to very hot sunlight for several weeks, with practically no rain. It seemed to me that the only explanation of the trouble with the first block and the success with the second block was the probable absorption of so much moisture by the sand and limestone that there was not enough water left for the setting of the cement. We accordingly played the hose on both sand and stone for some time, and then made up some concrete in the usual way, which proved as good as could be desired, and by following this plan the work proceeded without any more difficulty. The same thing has been brought to my attention since then and the remedy mentioned proved successful.

Very truly yours, E. A. MOLLAN.
Chicago, Jan. 16.

THE FAILURE OF LARGE BEAMS.

SIR: With reference to the letter by Mr. Samuel M. Green in your issue of Dec. 28, from the chemical analyses of the beam which broke in unloading, it is evident that this beam was made from Bessemer steel, in which the percentage of phosphorus was high. Other beams of equally high phosphorus may not have broken under similar conditions, but with this amount of phosphorus it is not surprising that the steel should be brittle, and since the brittleness of steel varies with the method of working, finishing temperatures, amount of oxygen in the steel, and other causes, it can be understood that a combination of several adverse conditions will produce very poor results. Owing to occasional such accidents, as recorded by Mr. Green, with Bessemer steel, open hearth steel is now generally specified for bridges and important structures, and, at the present time, a good many railroads, owing to having trouble on account of rails breaking, are seriously contemplating specifying open hearth rails.

In the case of the beams referred to by Mr. Green, cracks developed in the punching, and it was natural for these cracks to grow with every shock the beams received, thus causing a complete fracture through the beam.

Referring to the last paragraph of Mr. Green's article, it may be stated that a good many cases are on record of beams and other structural shapes failing as described by him. Most of these failures, however, have been with Bessemer steel. I do not recall any such failures with open hearth steel, where the specifications have been carefully written and lived up to.

I do not think it is necessary to test each beam, further than watching how it works in the shops. The brittleness of each beam can be determined by how it acts in being punched, sheared or coped, and by properly watching such points in the shop there is very little chance of a beam or any other shape being dangerously brittle without being detected, if the shop work is under the proper supervision. With these practical tests, and the regular physical tests of pulling and bending, and the chemical analysis of each heat used, I think that all engineers can feel perfectly confident that the steel will give reliable results.

Very truly yours, E. McL. LONG.

New York, Jan. 14.

THE PERMANENT WAY.

SIR: On account of being able to secure wood ties cheaply in the past, it was a comparatively easy matter to take care of the increased weight in rolling stock within a reasonable cost; but with wood ties soaring in the neighborhood of one dollar each, f.o.b., something else must be substituted to take their place, which will cost less and last longer, if possible. That portion of the track which performs the function of transmitting the load from the rails to the road bed must and will receive more serious thought and attention in the very near future.

Increasing the weight of the rail sections will not answer altogether, although it will help. Foundations in any and all cases must be provided, and a permanent way is the kind of a way desired, provided that in the end you effect a saving. You may not be able to do this in the matter of track alone, but when you take into consideration the saving to the rolling stock and your patrons' nerves, you will find that the properly constructed permanent way is by all means the cheapest in the final show-down. The nerves of your patrons form an asset that all companies must reckon with and rate very liberally, and I believe their value cannot be over-estimated, although some general managers and superintendents may think differently. Our aim should be to give an enjoyable as well as a convenient service; to be always on time; to glide our patrons gently around all curves, and over all switches, without their discovering that they have been passed through this ordeal. Conductors should not be humiliated in having to apologize to his passengers for picking them up from the opposite side of the car on account of the improper handling of the car around curves or for jolting them into a state of nervous prostration over a piece of special work or bad track, by his motorman. Motormen, as a rule, do not like to do this, but on account of track and car conditions at times, cannot help themselves and keep their schedule.

The permanent way must and will receive more consideration and study to get the greatest efficiency with the least cost; something that will be practicable is being carefully considered by many. In passing from the lighter to the heavier rail, in many instances the old rail can be cut up and used for cross-ties by using a well-devised rail clip or clamp to fasten the bases of the rails together; and then embedding the old-rail ties in a concrete foundation, making a permanent way. The selection of too heavy a rail section is poor economy when made at the sacrifice of the ties and foundation. The rail, tie and foundation should receive like consideration, and I believe it is the best policy to consider the tie first, the foundation next and then the rail. As a matter of fact the load, rail, tie and foundation are considered in the above order in determining what duties your ties have to perform. In a permanent way where the tie and foundation are synonymous terms, then the tie and foundation can be considered first. It is a fact, nevertheless, we should all understand that while a concrete beam of a certain size would answer in one place, in another locality it would be entirely out of place, and it will not perform the same duties under all conditions. A certain kind of construction in one place may prove to be a permanent way at a great saving in cost, but in another an absolute failure on account of local conditions. These local conditions, in many cases, that have caused failures are mostly due to the sub-grade conditions, such as a wet, poorly drained sub-grade, a quicksand sub-grade, or a soft spongy sub-grade. In all such cases, drainage should be provided and plenty of bearing surface secured. On all sub-grades of this kind a sheet concrete foundation for a permanent way should be used.

In a great many places, in the early days of horse cars, many of the tracks were paved with boulders, and to-day you will find these boulder pavements just as good as the day they were laid; they were not worth much when they were laid, and their value has not increased with age, but they were the best we had at that time. It is desirable to reconstruct these tracks on account of heavy equipment the increase in traffic has made necessary, and there is a vast amount of these old boulders on hand which can be used up in making a rubble concrete foundation. In many instances this old material amounts to a fourth or a third of the aggregate which we can use up in the foundation, and saves hauling it away, thereby cutting the cost of concrete in two while making just as good a job if properly done. I show by the East Washington St. paving how this is done. Concrete that would have cost $5.50 per cubic yard only cost $3.07.

In the permanent way of either the concrete beam or sheet concrete foundation, we must rely upon them to support our rails and the loads. Why not rely upon them to hold our rails in position by the addition of anchor bolts, as I have shown? It is my opinion that the scheme is practicable with properly designed appurtenances, with a continuous, Atlas or equally good, rail joint, with or without reinforcement under the joint, as the case may demand. With this idea in view I offer this plan as a suggestion and estimate that it will cost as follows:

In constructing either plan, the sub-grade is prepared, the drainage arranged, the track assembled and placed to the proper grade and line, then the foundation is constructed.

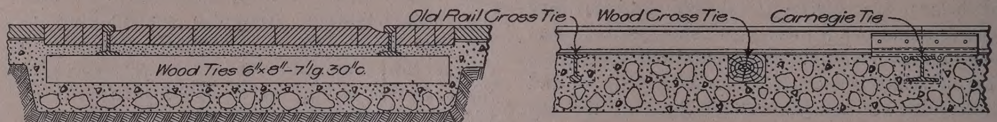
The cost per linear foot to construct a concrete-beam permanent way, exclusive of rails, rail joints, bolts and bonds, will be as follows:

To lay single track, furnish channel cross-tie of 5 lb. per foot, anchor bolts and clips, 5-ft. centers, with tie-plates between each tie with anchor bolts and clips, making anchorage 2½-ft. centers	$0.55
Excavation for track, 18 in. deep	.17
Concrete	1.35
Brick paving	.88
Total cost per linear foot	$2.95

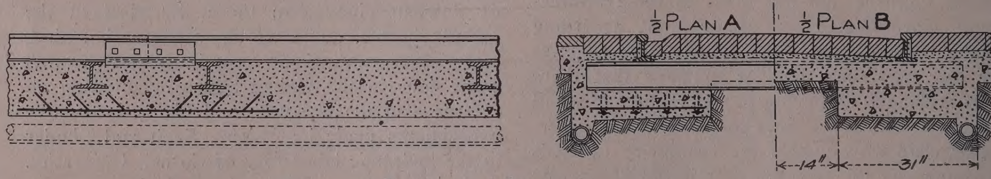
The cost per linear foot to construct a concrete-beam permanent way with Carnegie steel tie on 5-foot centers, exclusive of rails, joints, bolts and bonds will be as follows:

To lay single track and furnish Carnegie steel ties, bolts and clips; ties 14½ lb. per foot of tie, reinforcement under joints	$0.60
Excavation	.22
Concrete	1.35
Brick paving	.88
Total cost per linear foot	$3.05

The actual cost of rubble sheet concrete on the East Washington St. improvement was as follows: This piece of track was relaid with the old 5¾-in. steel that had been in service on this street for fourteen years. The rails were reversed, placing the outside of rail heads to the gauge side. The base was quite badly eaten away by rust and it was necessary to place the ties on 30-in. centers. The excavation was exceedingly heavy, running from 18 to 48 in. deep.



Construction Recently Employed in Fort Wayne.



Proposed Permanent Track Construction.

Cost per linear foot to take up old track and relay same, exclusive of rail, joints, bolts and bonds, including wood ties on 30-in. centers, spikes, laying the track to line and grade ready for foundation	$0.42
Excavation	.72
Concrete foundation, $3.07 per cu. yd	.74
Brick paving	.88
Total cost per linear foot	$2.76

An estimate on the same plan of work, on the same basis as East Washington St., using Carnegie steel tie or old steel rails for ties, is as follows:

Track laying, including ties and labor with necessary fastenings	$0.60
Excavation, 18 in. deep	.19
Concrete, $3.07 per cu. yd	.74
Brick paving	.88
Total cost per linear foot	$2.31

In the drawings I have endeavored to show three plans for laying the bricks between the rails.

Plan A, of which a half section is shown, contemplates a special block with corner clipped off, the brick next the rails laid on its side under the head, followed up with the special block, and this followed by the regular block in their order. Plan B contemplates using nothing but the regular block. Both plans contemplate laying the block parallel with the rails.

East Washington Street was laid as shown, with the Weber nose block, which were manufactured by the Metropolitan Paving Brick Co., of Canton, Ohio. This style of paving has proved to be very popular with city engineers and very satisfactory to the traveling public, and by its use street railroad companies can make and maintain a very neat appearing street and one that meets with the general approval of city authorities in connection with the T rail.

Very truly yours, H. L. WEBER.

Fort Wayne, Ind., Jan. 9.